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A Study of the Ecology and Epizoology of the Native Fauna of the Great Salt Lake Desert*

REPORT PERIOD
January 1, 1963 to March 31, 1964

ANNUAL SUMMARY PROGRESS REPORT
of the
Staff of Ecological and Epizoological Research
University of Utah
Dugway and Salt Lake City, Utah

ECOLOGY AND EPIZOOLOGY SERIES No. 108, JUNE 30, 1964

* This work was accomplished under Dugway Proving Ground U.S. Army Research and Development Contract with the University of Utah

The experimental animals used in these studies were housed, fed, and cared for in a humane manner and such care supervised by a competent biologist, in accordance with principles of laboratory animal care established by the National Society for Medical Research.

(6)

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INTRODUCTION

The staff of Ecology and Epizoology Research, University of Utah, presents this report in partial fulfillment of and in accordance with its U. S. Army Research and Development contract.

Basic essential disciplines relating to the study of diseases of wild and domestic animals in nature have been integrated and results of this joint effort are outlined in this report. The coordinated efforts of the fields of ecology, epizoology, microbiology, entomology, and zoology reflect the major aspects of the total capability and contributions made by this organization. During a period of twelve years, considerable growth in operational capability and in background knowledge of the field of disease ecology has been demonstrated as shown in the published literature. The one hundred and fifth publication in the field of ecology and epizoology has been completed and still more dealing with the subject are anticipated.

Although research is the main interest of the University of Utah, particularly as it pertains to understanding diseases in nature, emphasis has been placed on developing an operational capability regarding surveillance of the native animal populations and of disease incidence.

The diagnostic laboratory on the University of Utah campus has a staff of trained serologists and microbiologists who have developed and standardized procedures to give rapid diagnostic tests of wild animal sera, tissues and associated ectoparasitic vectors within a short time period. This unique and versatile facility and staff are geared to make it possible to determine enzootic or epizootic establishment of disease organisms among animal populations. Only after long practical experience in working with native animals and their natural diseases can a laboratory acquire competence in diagnostic procedures. Experience with comparative serology among various species of native rodents versus that of laboratory experimental animals shows that

extreme variance occurs, and that standardized serological tests set up for laboratory animals or humans cannot suffice for the sera of every rodent species tested. This knowledge has contributed toward an efficient laboratory diagnostic capability which, through trial and error and steady improvement, has resulted in competence and reliability in providing epizoological data as needed.

It is well known that rodents are involved as hosts of a number of zoonoses including plague, tularemia, tick-borne relapsing fever, Rocky Mountain spotted fever, murine typhus, and Colorado tick fever. Many of the Arbovirus infections involve birds and mosquitoes. These, too, may be found in rodents, rabbits, or other mammals occurring within the study area. Many of the host-ectoparasite-disease relationships can now be more fully understood, although there are many questions left unanswered. From our extensive survey program dealing with some of the diseases in wildlife, the diagnostic results indicate which ecologic sequence of relationships we should study, or upon which suspect species more, or less, effort should be directed.

Ecological studies of population fluctuations and changes in rodent-ectoparasite relationships are necessary in view of the fact that some epizootics have been directly correlated with population pressures and stresses from overcrowding. This may be the same mechnaism which changes a focal outbreak to an epizootic; or more specifically, an asymptomatic infection to frank clinical disease in a so-called resistant host during a population explosion. Many other environmental factors could affect the resistance mechanism or the susceptibility of a native animal community to any pathogenic microorganism which might be introduced. Equally important is the possibility that ecological factors within a given ecosystem may serve as natural barriers to the spread of such microorganisms.

Within the complexity of the ecosystem we continue to study vectors and their transmission cycles and potentialities of related organisms to vector or to reservoir infections. Attempts are made to prove within the laboratory what we have suspected takes place in nature. Thus it is important that a study be conducted concerning the animals living together in their environment; that we know their susceptibility or resistance to infections; and that the mechanisms are learned by which they might serve to provide ectoparasites with infected blood meals and how long viable organisms circulate in the peripheral blood of the host, or how long infected ectoparasites remain infective. All factors must be analyzed and correlated in an attempt to predict their destructive or disruptive effects on humans or their domestic livestock, so that control procedures can be implemented as required.

A significant wild animal rearing capability has resulted from the development of a faunal colony. Several species of native rodents are currently being studied and reared in sufficient numbers to provide experimental native animals for susceptibility and transmission studies. In addition, ectoparasite rearing colonies are maintained in support of experimental transmission and ecological studies.

OBJECTIVE SUMMARY

BA(a) Background Phase:

Literature Survey and Study Plan, sub-phase: A literature survey for relevant ecological and epidemiological information and Summary Survey report, along with a detailed plan, will be prepared for each new agent assigned.

Summary: Literature Survey and Study Plan, as per requirement, were submitted to the project officer previously. However, pertinent references will be cited in this report as needed.

BA(b) Baseline Sampling, sub-phase: Wildlife at the study area will be collected in numbers which are in consonance with good statistical design so as to clearly define the absence, or estimate the incidence, of the disease in the various species inhabiting the site.

Summary: Baseline sampling has been accomplished and data are presented in this report. These data are presented both in tabular and graphic form for the past report period, and are compared to those of previous years.

ES - Epizoological Surveillance Phase

Trapping and sampling procedures similar to those described in BA(b) sub-phase will be performed.

Summary: Data concerning this phase are treated in detail in the appendix.

PE(a) Predictive Epizoology Phase

Experimental transmission, sub-phase: Within the framework of this sub-phase it is our objective to perform susceptibility studies to estimate the species of animals which may be initially infected via the respiratory and other routes; as well as duration of the period that they may serve as a source

of infection, or as reservoirs of disease agents. For those which prove to be susceptible, transmission experiments showing vector transmission and *per os* estimates of efficiencies will be conducted. Susceptibility to rechallenge following inoculation via the above routes will also be studied. Due to unavailability of the Class III system, objectives pertaining to the above references to aerosol or respiratory infections will be postponed. Choice of experimental native animals for other routes of infection will be made according to availability and occurrence in important biotic communities.

Summary: Predictive epizoology studies, including susceptibility and experimental transmission, were performed. Further studies on duration of infection, rickettsemia, and carrier-state were initiated or completed. Data are presented both in table and text form within the appendix of this report so that analysis can be made and integrated with data from other related studies. All aerosol work requiring Class III hoods has been postponed pending adequate facilities.

PE(b) Ecological Observations, sub-phase

Relevant observations concerning wildlife populations, densities, and distribution by species, eco-geography, travel, wildlife community relationships, ecologic barriers to zoonotic transmission, etc., will be made in order to define those ecologic parameters important to disease transmission.

Summary: Ecological observations have been made relevant to population densities, distribution, and community relationships of the various animals occurring within the study area. The information is prepared in graphic form for the appendix of this report. Certain analyses have been presented. However, in many cases data have been presented and discussed, but analyses and conclusions are withheld for the sake of time and need for more data. The data concerning eco-geography, travel, and ecological barriers have been

gathered systematically, and with installation of improvements in data gathering and analysis at the beginning of the report period, relevant information is now kept on key-sort punch cards in addition to that routinely applied to the IBM system.

PE(c) Predictive Analysis, sub-phase

Data from PE(a) and PE(b) will be analyzed against the knowledge requirements criteria indicated in the "scope" section of the contract, as they pertain to "initial conditions", to the initiation of enzootic infection, and its rise and spread.

Summary: Predictive (correlative) analysis presented in the appendix in comparative tables and graphs supporting the PE(a) and PE(b) phases of this report concludes that all diseases of interest remain endemic at a relatively low rate, with no indications of an immediate outbreak. The information acquired in this phase is cumulative and results are never stable, therefore this analysis is more appropriately given in R and A reports.

Predictive IBM Analysis

Although basic work is one-half completed, the codification of data has been stopped by the Contracting Officer, because of lack of funds and a stated requirement. The University concludes that this is unfortunate.

EC - Eco-systems Phase

EC(a) and EC(b) - "Enclosed" and "open" area epizoological study. A series of experiments conducted under controlled field conditions upon written request of the project officer. Artificially-infected animals and/or their ectoparasites will be introduced into fenced, escape-proof confines, or in an open area with natural boundaries, for purposes of determining more realistically transmission potentials.

Summary: Eco-systems area epizoological studies were not conducted, since no real requirement has been received from the project officer.

CP - Control Procedures Phase

This study, which will result in the development of procedures, equipment, and materials to check the spread of, and/or eradicate the disease in question, will be completed prior to the initiation of the ES Phase investigations. This includes a continuous study of all physical and chemical means and methods appropriate for effective control of the disease agent, infected wildlife, or arthropod vectors. Critical methods of a plan for control will be field-tested.

Since the contractors are charged with the responsibility of keeping up-to-date on all methods of control for abating or reducing rodent or ectoparasite populations, or both, we have need of field testing experiments to determine the practicality of methods adopted. No literature is available concerning control of the same populations in the same biotic communities, or even in similar eco-systems as are present locally.

Summary: After a thorough perusal of the open literature on current methods of control in other eco-systems, and consultation with specialists in Universities, Public Health Service, local abatement districts, and commercial producers of chemicals, a plan was developed and submitted. Also, a field experiment was designed and completed. The time span of experimental study overlaps the report period; therefore, only partial results can be included in this report. Results obtained to date can be found in the appendix, and the completed phase report will be submitted upon conclusion of the experiment.

DISCUSSION

Predictive Epizoology Studies

PE(a) - Significant modification in basic laboratory procedures have been made in attempts to improve identification techniques. A staining procedure for Rickettsia rickettsii, developed by Dr. D. F. Gimenez,[1] was found to be superior to previously used methods and has been adapted for use in our laboratory.

Host susceptibility studies with various species of birds and rodents indicated that none of those tested were lethally susceptible to R. rickettsii by various routes of challenge. Variance was evident in their ability to free their tissues of this pathogen. Raptors did not develop long-term rickettsemia, whereas rickettsiae were isolated from serum samples of pigeons on the 4th to 15th days following subcutaneous inoculation of 10^5 fifty per cent lethal (LD_{50}) doses. Rickettsemia in jack rabbits and cottontails was determined to persist for periods from the 1st to 7th, and 4th to 6th days, respectively. Similar results were found in rodent species.

Complement-fixing (CF) antibody responses were not observed in raptors (with the exception of one marsh hawk), following ingestion of infected carcasses or following inoculation of R. rickettsii. Pigeons developed CF titers from 1:16 to 1:128.

All rodents and rabbits tested developed complement fixing antibody titers, with the exception of the bushy-tailed wood rat.

Seven species of rodents were tested for their susceptibility to infection with from one to three different strains of Bedsonia group organisms. Most were uniformly refractory to lethal infection. The deer mouse was more susceptible to subcutaneous infection with the Borg strain than was the pinyon mouse. Bacteremia developed in guinea pigs, deer mice, and desert wood rats by the first or second day following subcutaneous inoculations.

Organisms were isolated from the blood of these animals daily through the third to seventh days. Short-term CF antibody in low titer was determined in deer mice, desert wood rats, and guinea pigs, following inoculation of 10^4 to 10^6 mouse intracranial fifty per cent lethal doses ($MICLD_{50}$).

Domestic pigeons and sparrow hawks were tested for their susceptibility to Pasteurella pestis. Pigeons were not lethally susceptible to subcutaneous inoculation of up to 9.4×10^7 viable cells. Sparrow hawks survived feedings of infected rat carcasses. None developed CF antibody against the Fraction I antigen.

Background Endemicity Survey/Surveillance

BA and ES - Two isolations of Brucella neotomae were made from tissues of wood rats from North Skull Valley and Gold Hill. Brucella agglutinins were found in the sera of 53 specimens representing nine species. Animals from 15 of 19 areas were involved with Brucella for the first time.

Three strains of Pasteurella tularensis were isolated from jack rabbits and cottontails collected in Camelback Mountain, Vernon, and Grouse Creek areas. Also, agglutinins were found in 15 specimens of wildlife samples, and in 47 cattle and 93 sheep taken from scattered areas throughout the region.

No isolations of P. pestis were made in disease survey specimens. However, positive serological evidence was recorded in four specimens. Recent work in our laboratory confirms the conclusion that strains of lesser virulence occur and can be recovered periodically in the native fauna.

Rocky Mountain spotted fever CF antibody titers were recorded in 253 rabbit and rodent serum samples. The relationship of positives in different areas to the total number sampled remained fairly consistent with results obtained in previous years. No isolations were made from tissues or ectoparasite pools. Bird sera samples were all negative.

Q fever organisms were isolated from a chisel-toothed kangaroo rat from Dugway Valley. No isolations were made from ectoparasites. Sera positives among rodents and rabbits occurred at a rate of 0.8% of the sample, as compared to the previous year (8.7%). This decline is attributable to a normal subsiding of the epizootic reported in 1960. As found in previous years, all birds tested were negative for Q fever CF antibodies. A percentage of 5.7% of sheep sera were positive, but no cattle sera were found to contain phase II CF antibodies.

There were no isolations of Psittacosis-Lymphogranuloma-Venereum Group of organisms made from tissue or ectoparasite pools. Twenty-one wild rodent and rabbit samples and one bird were found to have psittacosis serum titers. Over 50% of sheep and 45 out of 180 cattle were sero-positive.

There were no new epizootics or significant increases in incidence of any of the diseases studied during this report period. Some new areas and species became involved either with isolations of pathogens or with serological evidences of occurrence. Such occurrences, however, probably fall substantially within the range of normal annual fluctuations and further observations and study will be maintained. In some cases involvement of new areas merely reflects increase or changes in area sampling which may or may not influence the resultant data.

During this report period considerable changes in trapping localities and standard collecting areas were made, in an attempt to collect more meaningful disease survey results. The survey area as it is now composed covers 5,500 square miles, with 29 standard collecting areas. These areas are grouped into five zones which are designated according to their relative distance and topographic location in northwestern Utah and the Great Basin. Native animals systematically collected during the four seasons from these areas are the source of all data for statistical analysis of disease

incidence herein reported. Within each of the 29 collecting areas, various biotic communities are systematically sampled in order to establish ecological relationships to geographic areas and occurrence of diseased animals. These, in turn, are correlated with the basic five zones described. Graphic analysis and tabulated data are presented in the appendix to provide the reader with more detailed knowledge of the specific areas and species involved. These are summarized by species, collecting area, and zones. Further data are provided which give total numbers collected, frequency of occurrence, relative trap nights per rodent, seasonal occurrence and zonal relationships.

A total of 2,064 wild mammals were collected and processed independently from the regular disease survey. These were collected during May and June, as requested by the project officer, and all were tested for the presence of certain Arboviruses.

To further study the plague focus, special collections were continued at Indian Farm Canyon as time permitted.

Ecological Observations

PE(b) - Ecological relationships have consistently been considered important factors in the study of the spread of infections. In addition to the data which are routinely gathered as collections continue year after year, new methods and approaches have been instituted which supplement regular disease survey collections and their related data. More information is now being gleaned from individual specimens, such as age characteristics, reproductive status, weather factors, infestation, etc. More concrete effort is expended to determine population densities, correlating infections with many of these factors and basic ecology of species involved. New methods of measuring population densities were investigated and the trap-night index has

been adopted as the most feasible method. This information is presented in more detail in the appendix, wherein the reader will be given a more complete insight into the complex problems of density estimates and comparisons.

A program of livetrap-bleed-release was instituted with jack rabbits, which will provide information relating to antibody persistence in the wild populations, infection rates, age relationships, etc. A similar trap and release study has been conducted with rodents on a fixed study plot in connection with a Control Procedures (CP) experiment.

A distribution and tick-host relationship study giving compiled data concerning the families of ticks collected throughout the Great Salt Lake Desert area is also presented in the appendix. These data give seasonal, as well as distributional, data when information is available.

Control Procedures

CP - Control procedures were studied in a field test wherein a 10-acre plot in a vegetated dune community was sprayed with a chlorinated hydrocarbon, Endrin. Rodent populations were estimated prior to application and at varying intervals afterward. Similar estimates made from trapping-mark-releasing information were made on a control plot in an equivalent area at the same time periods. Ectoparasite knock-down was determined by counting ectoparasites from rodents after capture. Positive evidence of control was determined. Final results and analyses, however, are not yet completed.

In addition to acquiring information about the effectiveness of a modern control method, the University of Utah staff of Ecology and Epizoology has gained first-hand experience with application of a fairly dangerous chemical under the most adverse wind and terrain conditions. They are also well experienced in procedures of follow-up and analysis which may be required at some future time.

Predictive (correlative) Analysis

PE(c) - Data are presented in the appendix, in comparative graphs and tables covering the calendar year 1963. The low level of incidence of the diseases of interest precludes any specific final correlation except to generally indicate endemicity. However, when these data are plotted in conjunction with those of previous years, they generally confirm the cyclic nature of the incidence rate and do not forecast any immediate epizootics. Specifically, they indicate a further decline from the incidence rate of brucellosis for 1960. Specific correlations over the years have been presented for tularemia, Q fever, and brucellosis in special reports, the titles of which appear in the appendix as required by Priority 6.

Venturing into future prediction and estimation of disease spread, and disease incidence in wildlife populations has been a necessary outgrowth of experience and data accumulated over the past 13 years of study. While practical application of predictive epizoology is paramount in importance to this area, it is extremely complex.

In attempting to correlate and stabilize the data amassed to date, the staff of Ecology and Epizoology Research has coded and submitted the disease survey information to data processing on IBM cards. All current data, after June 30, 1963, is processed as it accumulates. Part of the data, going backward in time to July, 1957 and still more back to 1954, has been processed and punched. However, the IBM work on past data has been stopped and the funding necessary for its continuance was terminated by the Contracting and Project Officers. This definitely closes out concerted efforts towards predictive analysis until the data processing is resumed.

APPENDIX

Infectious Disease Laboratory

PE(a) - Rocky Mountain spotted fever, Rickettsia rickettsii

Methods: All procedures used in the studies with R. rickettsii were the same as those described in the two previous Ecology and Epizoology Research annual reports, except for a change in the staining procedures.

During the past year this laboratory received the procedures for an improved method of staining smears of rickettsiae for microscopic examination. The method was developed by Dr. D. F. Gimenez, Communicable Disease Center, U. S. Public Health Service, Atlanta, Georgia. We have found this method to be greatly superior to the previously used Machiavello method, especially for staining rickettsiae in yolk sac smears. The following reagents and procedures are taken from a communication from Dr. Gimenez:

> "Reagents: A stock solution of carbol fuchsin is prepared by mixing 100 ml of 10% basic fuchsin in 95% ethanol, 250 ml. of 4% (V/V) aqueous phenol, and 650 ml of distilled water. It is kept 48 hours at 37°C before use. A 0.1 M sodium phosphate buffer solution at pH 7.45 is made by mixing 3.5 ml of 0.2 M NaH_2PO_4, 15.5 ml of 0.2 M Na_2HPO_4, and 19 ml of distilled water. The working solution of carbol basic fuchsin is prepared by mixing 4 ml of stock solution with 10 ml pH 7.45 buffer. This is immediately filtered, and filtered again before every stain. It remains suitable for about 48 hours. The other solutions are 0.8% aqueous malachite green oxalate, 4% aqueous Fe $(NO_3)_3$, 9H O, and 1% aqueous fast green.
>
> "Procedures: Staining Procedure A for all rickettsiae except R. tsutsugamushi, and psittacosis, is as follows: A very thin smear is made from yolk sac tissue from which the yolk has been drained as much as possible. After air drying, and either with or without fixing by passing through a flame, the smear is covered with carbol fuchsin (working solution) and let stand 1 to 2 minutes. After being washed thoroughly in tap water, the smear is covered with malachite green solution for 6 to 9 seconds, washed with tap water, covered again with malachite green solution for 6 to 9 seconds, again washed with tap water, and the slide finally dried with absorbent paper."

A modification of this procedure is used for staining of R. tsutsugamushi. Contrary to Dr. Gimenez's notation that his Procedure A was not

satisfactory for staining the psittacosis agent, we have observed that this procedure gives better contrast with the elementary bodies than did the Machiavello method. Dr. C. C. Shepard[2] has stated that the Procedure A should give good results in staining psittacosis organisms.

We have modified this procedure by blotting the slide dry after the second application of malachite green oxalate, rather than washing in tap water and then drying. Washing with the locally available tap water of a high total solids content, changes the malachite green to a blue color, which results in less of a contrast between the red-stained organisms and the counter stain.

The optimal incubation temperatures for embryonated hen's eggs inoculated with psittacosis group agents or R. rickettsii, to obtain maximum growth of these organisms, are 37°C and 35°C, respectively (Stoenner, et al.,[3] Eddie, B.[4]). In order to be able to use our egg incubators more efficiently a study was undertaken in our laboratory to determine optimal incubation temperatures under the conditions of our facilities. Eggs were incubated at 37°C prior to the inoculation of the organisms. The inoculated eggs were then incubated at the desired temperature. Five-day-old embryonated eggs were used for studies on R. rickettsii and 7-day-old embryonated eggs were used for studies on psittacosis.

The following 50% egg lethal doses (ELD_{50}) of a stock suspension of R. rickettsii, strain SFR #49, were observed (standard error included):

Inoculated eggs incubated at 35°C --- 1.5×10^7 (6.0×10^6 to 3.6×10^7).
Inoculated eggs incubated at 37°C --- 3.2×10^5 (1.7×10^5 to 6.0×10^5).

The following ELD_{50} doses of a stock suspension of the New Jersey Turkey strain of psittacosis group organisms were observed (standard error included):

Inoculated eggs incubated at 35°C --- 1.9×10^7 (1.0×10^7 to 3.6×10^7).
Inoculated eggs incubated at 37°C --- 5.2×10^6 (2.6×10^6 to 1.0×10^7).

It is evident that there is a significant difference in the susceptibility of embryonated eggs incubated at different temperatures to infection with R. rickettsii. All eggs inoculated with material for attempted isolation of rickettsiae will be incubated at 35°C. The effect of incubation temperature on the susceptibility of embryonated eggs to infection with the New Jersey Turkey strain borders on being significant. Until we can demonstrate a definite significant difference in susceptibility of eggs incubated at different temperatures, we will incubate all eggs inoculated with material for attempted isolations of culture psittacosis organisms at the recommended temperature of 37°C.

Host Susceptibility:

Aves - Several species of birds were tested for their susceptibility to infection with R. rickettsii. However, only enough domestic pigeons, Columba livia, were available to attempt to determine susceptibility on a statistical basis. The responses of all other species of birds to infection are discussed elsewhere in this report. The highest concentration of rickettsiae inoculated into pigeons (3.98×10^4 ELD_{50} doses) infected 41.4%. Lesser concentrations of rickettsiae did not infect any of the birds (Table 1). The per cent infected was based on the CF antibody response of birds 28 days after inoculation of the rickettsiae. None of the pigeons died of the infection.

Rodents - Three species of rodents, Cricetus auratus, golden hamster; Rattus exulans, Polynesian rat; and Peromyscus californicus, California mouse, were tested for their susceptibility to subcutaneous infection with R. rickettsii. Although none of these animals are native to the Great Basin area, it was of interest to determine their susceptibility to observe if they could possibly be used to replace one of the standard laboratory animals

in the study of RMsf. The 50% infective dose expressed in ELD_{50} doses for these rodents is summarized in Table 1. None of these animals were lethally susceptible.

TABLE 1. The susceptibility of wildlife to subcutaneous infection with Rickettsia rickettsii strain SFR #49.

Species	ID_{50}*
Columba livia	
Domestic pigeon	$>3.98 \times 10^4$ (41.4% infected at this dose)
Cricetus auratus	
Golden hamster	1.6×10^3 (3.1×10^2 to 8.0×10^3)
Rattus exulans	
Polynesian rat	23.4 (7.7 to 71.2)
Peromyscus californicus	
California mouse	12.6 (5.4 to 29.0)

* Expressed in LD_{50} doses (Pizzi, M.)[5]

The possibility of infecting guinea pigs with R. rickettsii by the oral route by allowing the animals to feed on infected spleen and liver, or to drink contaminated water, was tested. Food and water were withheld from ten guinea pigs for 24 hours. Four of the animals were then given nothing but infected spleens and livers for the next 24 hours. Six were given only contaminated water. Three of the animals ate the infected tissue. It is not known if any guinea pigs consumed any contaminated water, or the volume taken if they did. Water consumed could not be determined because of loss of volume by evaporation and dripping. None of these animals developed symptoms of spotted fever or immunity to challenge; although two, given contaminated water, developed CF antibody titers of 1:128.

The possibility of infecting guinea pigs by the intranasal route was also investigated. Five guinea pigs were inoculated intranasally with 0.5 ml of undiluted egg yolk sac homogenate containing 10^6 ELD_{50} doses of R. rickettsii.

Two normal guinea pigs were housed with infected animals. The five exposed guinea pigs developed typical spotted fever CF antibody titers of 1:128, and immunity to challenge. The normal animals did not. Although guinea pigs can be infected by the intranasal route, this experiment did not indicate that such infected animals could transmit the disease to normal animals via the same route.

Carrier Potential:

Aves - Observations on persistence of R. rickettsii in the tissues of pigeons infected by inoculation of 10^5 ELD_{50} doses of rickettsiae have been summarized in Table 2. All tissues tested were positive at one week, the spleen and liver were positive at two weeks. No samples were collected on the third week, and those collected on the fourth week were negative.

TABLE 2. Persistence of rickettsiae in pigeons infected by the subcutaneous inoculation of 10^5 ELD_{50} doses of Rickettsia rickettsii.*

	Weeks following inoculation of rickettsiae		
Tissue	1	2	4
Heart muscle	+	-	-
Kidney	+	-	-
Liver	+	+	-
Brain	+	-	-
Spleen	+	+	-

* Tissues of five pigeons were pooled at each sampling period.

Rickettsemia:

Aves - Three magpies, one marsh hawk, three sparrow hawks, and 35 domestic pigeons were inoculated subcutaneously with 10^5 ELD_{50} doses of rickettsiae and then tested for rickettsemia. A second group of pigeons was inoculated with 10^6 ELD_{50s}. An additional two sparrow hawks were fed 6 and 8 grams of infected guinea pig liver and spleen. A sparrow hawk that did not eat infected tissue was used as a control. Results of these studies are summarized in Table 3. Rickettsiae were isolated from blood samples of pigeons collected on the 4th, 5th, 7th, 9th, 11th, and 15th days after inoculation. None were isolated from blood samples of hawks or magpies.

TABLE 3. Rickettsemia in birds after subcutaneous or oral exposure to *Rickettsia rickettsii* strain SFR #49.

Species	Number	Route	Dose	Days following inoculation* 1	2	3	4	5	6	7	9	11	15	16
Circus cyaneus														
Marsh hawk	1	S.C.	10^5 ELD_{50}	-	-			-		-	-			
Falco sparverius														
Sparrow hawk	1	S.C.	10^5 ELD_{50}											
	2	S.C.	10^5 ELD_{50}	-	-			-		-	-			
	3	S.C.	10^5 ELD_{50}	-	-			-		-	-			
	4	Control	none	-	-			-		-	-			
	5	Oral	6 grams	-	-			-		-	-			
	6	Oral	8 grams	-	-			-		-	-			
Pica pica														
Black-billed magpie	467**	S.C.	10^5 ELD_{50}	-	-			-		-	-			
	493	S.C.	10^5 ELD_{50}	-	-			-		-	-			
	633	S.C.	10^5 ELD_{50}	-	-			-		-	-			
Columba livia														
Domestic pigeon	Expt. 1***	S.C.	10^5 ELD_{50}	0/5	0/5	0/5	2/5	3/5	0/5	3/5	3/5			0/5
	Expt. 2****	S.C.	10^6 ELD_{50}			-		+		+	+	+	+	

* Each marsh hawk, sparrow hawk, and magpie was bled repeatedly.

** Magpie No. 467 died on the 5th day of causes not diagnosed as RMsf.

*** Pigeon Expt. #1. Five pigeons were sacrificed at each interval

**** Pigeon Expt. #2. Five pigeons were bled at each interval and their blood was pooled and tested for rickettsiae.

S.C. = Subcutaneous.

Lagomorphs - Seven cottontails, S. audubonii, trapped in the Government Creek area during December, 1963, were tested for rickettsemia following subcutaneous inoculation of 10^5 ELD_{50} doses of organisms. Results of these observations are summarized in Table 4. In this study, conducted during the months of January and February, 1964, rickettsiae were isolated only three times from the blood of the cottontails. These isolations were from one rabbit on the 4th day, one on the 6th day, and from another on the 8th day.

An adult jack rabbit, L. californicus, which was raised from infancy in our Faunal Laboratory, was utilized for experimental studies. It was infected by subcutaneous inoculation of 10^5 ELD_{50} doses of rickettsiae. Blood samples were collected at intervals to determine the presence of a rickettsemia, and to study the antibody response of the animal. Rickettsiae were recovered from the blood on the 1st, 3rd, 5th, and 7th days; but not on the 9th or the 13th day (Table 4).

TABLE 4. Rickettsemia in the cottontail and jack rabbit inoculated with 10^5 ELD_{50} doses of Rickettsia rickettsii, strain SFR #49.

	Days following inoculation										
Animal	1	2	3	4	5	6	7	8	9	10	13
Cottontail											
No. 1		-		-		-		-		-	
2		-		+		-		-		-	
3		-		-		-		-		-	
4		-		-		-		-		-	
5		-		-		-		-		-	
6		-		-		-		+		-	
7		-		-		+		-		-	
Jack rabbit											
No. 1	+		+		+		+		-		-

Rodents - Development and persistence of rickettsemia in the antelope ground squirrel, pinyon mouse, canyon mouse, and pocket gopher were studied following subcutaneous inoculation of 10^5 ELD_{50} doses of rickettsiae. Results of this study are summarized in Table 5. Rickettsiae were recovered from the blood of many antelope ground squirrels for up to 12 days; from the blood of pinyon and canyon mice at two and four days; and at two days from the single gopher studied.

TABLE 5. Rickettsemia in rodents following subcutaneous inoculation of 10^5 ELD_{50} doses of Rickettsia rickettsii strain SFR #49.

Species	Days following inoculation of rickettsiae*							
	2	4	6	8	10	12	14	16
Antelope ground squirrel	4/5	5/5	5/5	4/5	1/5	1/5	0/5	0/5
Pinyon mouse	4/5	3/5	0/5	0/5				
Canyon mouse	3/4	1/4	0/4	0/4				
Pocket gopher	1/3			0/1				

* All animals were sacrificed for blood samples at each interval.

A study to determine the concentration of rickettsiae in the blood of infected montane voles was completed. A group of voles were inoculated with 10^5 ELD_{50} doses of rickettsiae and daily blood samples were collected from five voles, pooled and homogenized in a blendor. Appropriate dilutions of the homogenate were prepared and inoculated into 5-day-old embryonated hen's eggs. No definite conclusions as to the concentration of rickettsiae in the blood samples could be made by observing the deaths of embryos because nonspecific deaths of embryos occurred in all groups of inoculated eggs. The yolk sacs of all dead embryos were harvested, homogenized, and inoculated into guinea pigs according to individual blood samples and dilution. Results of this study are summarized in Table 6. Rickettsiae were isolated from the blood of voles on the 4th, 5th, and 6th days. Concentrations of rickettsiae of 10 egg lethal doses (ELDs), 1,000 ELDs, and 100 ELDs per 0.5 ml of blood, respectively, were demonstrated by this method.

TABLE 6. Concentration of rickettsiae in the blood of R. rickettsii subcutaneously infected montane voles, Microtus montanus.

Blood dilutions inoculated into embryonated eggs	Days following inoculation of rickettsiae*									
	1	2	3	4	5	6	7	8	9	10
10^0	-		-	+	+	+	-	-		-
10^1	-		-	+	+	+	-	-		-
10^2	-		-	-	+	+	-	-		-
10^3	-		-	-	+	-	-	-		-
10^4	-		-	-	-	-	-	-		-
10^5	-		-	-	-	-	-	-		-

* A positive was indicated by development of spotted fever and resistance to challenge in guinea pigs inoculated with yolk sacs of embryos dead after the inoculation of blood from inoculated voles.

A study of the effect of previous infection with R. rickettsii on suppressing subsequent infection with the same organism in montane voles was completed. The observations have been summarized in Table 7. In this study a group of voles was infected with rickettsiae by the subcutaneous inoculation of 10^5 ELD_{50} doses of rickettsiae. These animals were held for two months, then the survivors and a group of normal voles were inoculated with the same dose of organisms that was originally given. It is evident that the treated group retained a solid immunity to challenge, whereas the normals were susceptible to infection.

TABLE 7. Rickettsemia in normal and immune montane voles following the subcutaneous inoculation of 10^5 ELD_{50} doses of rickettsiae.

Voles	Days following inoculation of rickettsiae*				
	2	5	6	8	10
Normal	+	+	+	+	-
Immune**	-	-	-	-	-

* The blood of five animals of each group were pooled and tested at each interval.

** Two months after subcutaneous inoculation of 10^5 ELD_{50} doses of rickettsiae.

Complement Fixing Antibody Response:

Aves - Pigeons, sparrow hawks, magpies and a marsh hawk were tested for their development of CF antibody following ingestion or inoculation of R. rickettsii. Three sparrow hawks and three magpies did not develop detectable antibody following the subcutaneous inoculation of 10^5 ELD_{50} doses of the rickettsiae. Two sparrow hawks fed infected spleen and liver also did not develop CF antibody. Antibody titers of 1:32 were observed in the marsh hawk following subcutaneous inoculation of rickettsiae when the commercial antigen was diluted 1:6, but not when diluted 1:12. Pigeons readily developed CF antibody titers ranging from 1:16 to 1:128 following inoculation of rickettsiae. These titers declined rapidly except in one pigeon where the titer remained at or near 1:64 for up to 16 weeks. An optimal antigen dilution of 1:20 was used for the pigeon analysis. Results of these observations have been summarized in Table 8.

TABLE 8. Rocky Mountain spotted fever complement fixing antibody response in marsh hawks and pigeons inoculated subcutaneously with R. rickettsii.

Bird No.	Antigen Dilution	Weeks after inoculation*													
		0	1	2	3	4	5	6	8	10	12	13	14	15	16
Pigeon															
935	1:20**	<16	<16	<16		<16	<16	<16	<16						
920	same	<16	<16	>64		>64	64	<16	<16	16	<16	<16	<16	<16	<16
6537	same	<16	<16	<16		<16	<16								
908	same	<16	<16	32		16	32	16	<16	<16	<16	<16	<16	<16	<16
949	same	<16	<16	<16		<16	64	32							
617	same	<16	<16	<16		32	32	64	32	16	16	<16	<16	<16	<16
697	same	<16	<16												
931	same	<16	<16	<16		>64	128	128	128	64	64	64	64	16	64
919	same	<16	<16	32		>64	128	128	64	32	16	<16	<16	64	<16
698	same	<16	<16	<16		16	64	64	32	16	16	<16	<16	<16	<16
Marsh Hawk	1:6***	<16	<16	<16	32	32	<16								
	1:12	<16	<16	<16	<16	<16	<16								

*Titers expressed as the reciprocal of the highest serum dilution giving 50% lysis of sensitized sheep red blood cells.

**Antigen dilution based on optimal proportion titration with known positive pigeon serum.

***Optimal antigen proportion not known. Dilutions of antigen used were arbitrarily selected.

Lagomorphs - The development of CF antibody in one jack rabbit inoculated with 10^5 ELD_{50} doses of rickettsiae was observed. An optimal antigen dilution of 1:12 resulted in the following titers being observed. Pre-test, negative; 1 week, negative; 2 weeks, 1:32; and 3 weeks, 1:128.

The CF antibody response of seven cottontails inoculated with rickettsiae as described in the section on rickettsemia was also observed. These observations are summarized in Table 9. All but one cottontail had CF antibody prior to experimental infection. These titers raised one to three dilutions in four of the cottontails and remained relatively unchanged in three. There was no apparent difference in results obtained by the two antigen concentrations, except in animal No. 1, where 1:16 titers were observed with 1:6 antigen, and no positives after the pre-test with the 1:20 antigen.

Rodents - Development and persistence of RMsf CF antibody in bushy-tailed wood rats, Neotoma cinerea; and pinyon mice, P. truei, following inoculation of 10^5 ELD_{50} doses of rickettsiae were observed. Results are summarized in Table 10. Bushy-tailed wood rats, in general, did not develop CF antibody as did other rodents previously tested. Pinyon mice developed antibody that remained at titers of 1:16 to 1:128 for 14 weeks.

TABLE 9. Rocky Mountain spotted fever complement fixing antibody response in cottontails inoculated subcutaneously with Rickettsia rickettsii, Strain SFR #49.

Time in Weeks	Cottontail number and antigen dilution*, **													
	1		2		3		4		5		6		7	
	1:6	1:20	1:6	1:20	1:6	1;20	1:6	1:20	1:6	1:20	1:6	1:20	1:6	1:20
0	16	16	32	32	64	64	32	16	<16	<16	16	16	16	16
2	16	<16	128	128	64	128	32	32	16	16	128	128	64	64
3	16	<16	128	128	128	64	32	32	16	16	128	128	128	128
4	16	<16	128	64	64	32	32	32			128	128	64	64
5	16	<16	128	64	64	64	32	32			128	64	128	64
6	<16	<16	64	64	64	32	32	32			128	64	64	32
7	<16	<16	64	32	32	32	32	32			64	64	128	64

* An antigen concentration of 1:20 was found to be optimal for diagnosis of RMsf CF antibody in cottontails. The 1:6 concentration was done to compare results with previous studies.

** Titers expressed as the reciprocal of the highest sera dilution giving 50% lysis of sensitized sheep red blood cells.

TABLE 10. Rocky Mountain spotted fever complement antibody in bushy-tailed wood rats and pinyon mice inoculated subcutaneously with Rickettsia rickettsii, Strain SFR #49.

Time Weeks	Bushy-tailed wood rats**					Pinyon mice sacrificed				
	1	2	3	4	5	1	2	3	4	5
0	<16	<16	<16	<16	<16	<16	<16	<16	<16	<16
1	<16	<16	<16	<16	<16					
2	<16	<16	<16	<16	<16					
3	<16	<16	<16	<16	<16	16	64	<16	<16	<16
4	128	<16	<16	<16	<16	16	16	64	<16	<16
5						64	16	128	16	32
6	64	<16	<16	16	<16	32	16	16	<16	<16
8						128	32	32	16	128
10						64	32	32	16	32
12						128	32	64	32	64
14						32	64	16	128	32

* Titers expressed as the reciprocal of the highest sera dilution giving 50% lysis of sensitized sheep red blood cells.

** The same five individual bushy-tailed wood rats were beld throughout this study.

*** Five pinyon mice were sacrificed at each time interval for serum.

Discussion:

Aves - There has been no report in the literature indicating that birds become infected with R. rickettsii in nature. However, many species of ground-feeding birds have been reported to be hosts of the ticks Amblyomma americanus (Robinson)[6], and Haemaphysalis leporis-palustris (Cooley)[7]. Both of these ticks are known vectors of RMsf (Eklund, et al.)[8]. Parker et al.,[9] suggested that infected H. leporis-palustris may be important in the spread of RMsf from one area to another through being carried considerable distances by ground-feeding birds.

We have observed that at least one species of bird, the pigeon, is susceptible to spotted fever; and that three species, sparrow hawks, marsh hawks, and magpies, are resistant to infection. Pigeons developed a rickettsemia by the fourth day after inoculation of rickettsiae. This rickettsemia persisted for 5 to 11 days, depending on the infecting dose, and the individual response of the birds. Pigeons cleared their tissue of rickettsiae at about the same rate as previously observed in experimentally infected rodents (Ann. Repts. Nos. 70 and 100).[10, 11] A wide variation in the antibody response of individual pigeons was observed. Some failed to develop detectable antibody, whereas others developed titers of 1:64 or greater that persisted for at least 16 weeks in some birds. Based on these observations it is evident that the pigeon could be a host of this disease in nature. Scavenger birds and birds of prey apparently are resistant to infection with this rickettsiae, and would only contribute to the spread of RMsf by transporting infected ticks as suggested by Parker et al.[9]

Lagomorphs - Observations of the presence of CF and/or toxin neutralizing antibody in the sera of jack rabbits collected in the field indicate that this animal is of importance in the maintenance and dissemination of R. rickettsii in nature (Ann. Rept. No. 100;[11] Philip et al.;[12] and Stoenner

et al.[13] No observations of experimental infection studies in the jack rabbit have been published. Although we had only one laboratory-reared animal to study, this was sufficient to demonstrate that the jack rabbit is susceptible to infection with R. rickettsii and that a rickettsemia persisting for at least seven days will develop in these animals. Additional animals will be obtained for further studies.

A third experiment on the rickettsemia in cottontails has been completed. This study was conducted in an effort to clarify the conflicting results observed in the two earlier similar studies, one in June 1961 and one in February 1962.[10, 11] As a result of these two studies it could not be concluded whether a seasonal variation in the susceptibility of cottontails was the cause of the conflicting results, or whether the observed differences were due to active immunity in animals collected from the field. Cottontails used in the present study were collected during December 1963, and January 1964 in the Government Creek area. Experimental work was initiated on January 30, 1964. Results of this study (Table 4) were similar to the observations made in the study conducted in June 1961, and contrary to those of February 1962.

It may be concluded, therefore, that the variations in the results of the two previous experiments were not due to seasonal variation in susceptibility, but more likely to immunity in the recently trapped animals. Those animals which were tested in February of 1962 and found to have persisting rickettsemia, were trapped in April and May of 1961, as were the cottontails tested in June of 1961 which had a markedly reduced rickettsemia. Apparently, the holding of the cottontails in captivity for eight to nine months was sufficient for the immunity to decrease to a level that a rickettsemia developed in the inoculated animals. There seemed to be no correlation between the presence or absence of CF antibody prior to inoculation and the resulting rickettsemia.

Rodents - The susceptibility of the three species of rodents, golden hamsters, California mice, and Polynesian rats, was not significantly different from that of the previously tested rodents.[10, 11] Susceptibility of the hamsters was similar to that previously reported in the canyon mouse, pinyon mouse, antelope ground squirrel, and albino laboratory mouse. Susceptibility of the California mouse and the Polynesian rat was similar to that of the desert wood rat. None of these three species were as susceptible as the guinea pig, montane vole, or deer mouse. All of these determinations were based on the development of CF antibody in the animals being tested.

Development and persistence of rickettsemia in the pinyon mouse, canyon mouse, and pocket gopher were not unlike that observed in several other species of rodents as summarized in previous reports.[10, 11] The rickettsemia in the antelope ground squirrel, however, was much more persistent than that observed in any other rodent, with the exception of the long-tailed pocket mouse and the least chipmunk. The antelope ground squirrel could contribute more to the survival of R. rickettsii in nature than most rodents. This may be of even more importance because of this squirrel's local abundance and wide distribution throughout various vegetative communities in the Great Basin area,[10, 11] (Vest)[14].

We reported earlier that the bushy-tailed wood rat was very resistant to infection with R. rickettsii.[11] These data were strengthened by the observation that these animals do not form appreciable CF antibody after the inoculation of high doses of rickettsiae. The CF antibody response of pinyon mice was much like that reported to occur in several other species.

Psittacosis Group of Microorganisms (Miygawanella spp., or Bedsoniae)

Definition of terminology: The reader should be aware that the present status of classification of what is generally referred to as the "psittacosis-lymphogranuloma venereum group of agents" is not yet clearly defined, and that there are several synonymous terms in common usage. Bergey's Manual of Determinative Bacteriology (Breed et al.)[15] presently classifies these agents in the genus Miygawanella, and assigns specific names on the basis of the disease caused by the agent. However, cross toxin neutralization, cross infection neutralization, and cross complement fixation reactions among these agents occur. Meyer[16] prefers to group these organisms together and refer to them by the family name, Bedsoniae, or commonly as bedsonia (the terminology we shall use here). These organisms have also been referred to as Rickettsiae, Chlamy dozoon, Rickettsiaformis, Mycobacterium, and Ehrlichia species in some literature. Many writers refer to them as agents of the disease under discussion and do not use scientific names. In a recent publication by Moulder,[17] evidence was presented which indicates that these organisms should not be classified as viruses, or rickettsiae, but as a form of small bacteria. For reasons of simplifying the discussion in this report, the occurrence of these organisms in the blood of experimentally infected rodents will be referred to as bacteremia.

Methods: Discussions of the methods used in our laboratory for the study of psittacosis have been presented in detail in previous reports (Ecol. and Epiz. Plans,[18] Sidwell et al.)[19] We include here only a brief discussion of these methods.

a. Serology: Psittacosis diagnostic antigen produced by Lederle Laboratories was utilized in the complement fixation tests.

b. Isolation of agents of psittacosis: Isolation of agents from experimentally infected tissue was by one or both of the following methods:

1) Inoculation into 21-day old Swiss-Webster albino mice. Three blind passages were completed before a sample was termed negative. A mouse was determined to be positive when it developed typical pathology of psittacosis.

2) Inoculation into 6- to 8-day old embryonated hen's eggs from flocks on an antibiotic-free diet. Inoculated eggs were incubated at 37°C. Smears were prepared for microscopic examination for elementary bodies from all eggs dying after 48 hours following inoculation of tissue being tested. Blind passages were not done in eggs.

c. Diluent: Brain Heart Infusion (BHI) broth (produced by Difco Laboratories, Cat. No. B37) with 500 micrograms streptomycin sulfate per ml, was used as the standard diluting fluid. When contaminated materials were encountered, TSS (Meyer and Eddie)[20] solution was used in place of BHI broth.

d. Standard titrations of agent stock cultures: Quantitative determination of the concentration of organisms in any given homogenate was made by intraperitoneal (IP) or intracranial (IC) inoculation of albino laboratory mice; or by yolk sac inoculation in 6- to 8-day old embryonated hen's eggs. Infection in IP inoculated mice was diagnosed by CF antibody response. Concentrations of organisms were then expressed as: (1) white mouse IP 50% infective dose ($MIPID_{50}$); (2) white mouse IC 50% lethal dose ($MICLD_{50}$); and (3) embryonated hen's egg yolk sac inoculation 50% lethal dose (ELD_{50}).

Relationships of these different methods of determining quantitatively the concentration of organisms were studied. Titrations of a stock culture of the 6BC strain of bedsonia were made by each of the above methods.

The following concentrations of organisms in the stock cultures were obtained:

$MIPID_{50}$s ... 1×10^6 (5.9×10^5 to 1.7×10^6)
$MICLD_{50}$s ... 2×10^6 (1×10^6 to 3.9×10^6)
ELD_{50}s ... 3.2×10 (3.0×10^7 to 3.3×10^7)

It is evident that there is no significant difference between the titrations by the white mouse IP and IC routes, but the use of embryonated hen's eggs is significantly more sensitive a procedure. The susceptibility of wildlife to bedsonia agents will be reported in terms of $MICLD_{50}$s and/or ELD_{50}s.

Preferably, infective doses for wildlife will be reported in terms of both units. A discussion of incubation temperatures of inoculated eggs, will be found in Methods section, under Rocky Mountain spotted fever.

e. Strains of bedsonia: Bedsoniae agents presently on hand in our laboratory and available for experimental study, are summarized in Table 11.

f. Staining of organism: A discussion of the staining procedures used will be found in the Methods section under RMsf.

TABLE 11. Strains of Bedsoniae presently available for our experimental infection studies.

Origin of isolate	Strain	Culture received from
Avian		
Parakeet	6BC	Drs. K. F. Meyer and B. Eddie George Williams Hooper Foundation, San Francisco, Calif.
Domestic turkey	New Jersey turkey	Drs. K. F. Meyer and B. Eddie
White-winged dove	TSDH Virus Lab #29052-127	Dr. J. V. Irons, Texas State Department of Health
Mammalian		
Sheep (enzootic abortion in ewes)	EAE B-577	Dr. J. Storz, Utah State Univ. Logan, Utah
Cattle (sporadic bovine encephalomyelitis)	BEV LW-623	Dr. J. Storz
Sheep (feces of latently infected sheep)	MO-907	Dr. J. Storz
Human		
Louisiana	Borg	Dr. H. J. Hearn, Fort Detrick, Maryland

Host Susceptibility:

Rodents - Seven species of rodents were tested for their susceptibility to infection with one to three different strains of bedsonia group organisms. Results of these observations are summarized in Table 12. All species of rodents were uniformly resistant to lethal infection with these organisms. Susceptibility was therefore based on the CF antibody response of rodents sacrificed 4 weeks after inoculation of serial dilutions of stock cultures.

All of the grasshopper mice, Ord kangaroo rats, harvest mice, and pinyon mice utilized were classified as adults, based on their having completed their molts. Deer mice and desert wood rats were all sub-adults, as determined by their peltage, except for the deer mice used for IC inoculation, which were classed as juveniles.

Deer mice and Ord kangaroo rats were resistant to infection with the NJT strain with their ID_{50} ranges for all routes of inoculation being 10^3 to 10^6 $MICLD_{50s}$. Deer mice, desert wood rats, harvest mice, and montane voles were observed to be significantly more resistant to infection with strain 6BC by the S.C. route than are the pinyon mice and Ord kangaroo rats. The deer mouse was the only animal tested for susceptibility to infection with strain 6BC by other than the S.C. route of inoculation. These rodents were also resistant by the I.C. route, but were significantly more susceptible to infection by the I.P. route. The deer mouse was significantly more susceptible to S.C. infection with the Borg strain than was the pinyom mouse. Although grasshopper mice were tested for their susceptibility to infection with the Borg strain, the results were inconclusive because of the strong anticomplementary activity of their serum, which interfered with the analysis for CF antibody.

TABLE 12. Susceptibility of rodents to infection with organisms of the Bedsoniae group, as determined by the development of complement fixing antibody in inoculated rodents.

Species	Bedsonia strain	Route	ID_{50}s Expressed in $MICLD_{50}$s	ID_{50}s Expressed in ELD_{50}s
Deer mouse	Borg	S.C.	22 (12 to 40)	
Deer mouse	6BC	I.P.	110 (44 to 278)	1.8×10^3 (7×10^2 to 4.4×10^3)
Deer mouse	6BC	I.C.*	$>2 \times 10^6$	$>3.2 \times 10^7$
Deer mouse	6BC	S.C.*	$>2 \times 10^6$	$>3.2 \times 10^7$
Deer mouse	NJT	I.P.	4.8×10^3 (1.8×10^3 to 1.3×10^4)	5.5×10^3 (2.0×10^3 to 1.5×10^4)
Deer mouse	NJT	I.C.	2.5×10^3 (4.7×10^2 to 1.3×10^4)	2.8×10^3 (5.2×10^2 to 1.5×10^4)
Deer mouse	NJT	S.C.	$>4.6 \times 10^6$	$>5.2 \times 10^6$
Deer mouse	BEV	I.P.		$>1.3 \times 10^4$
Deer mouse	BEV	I.C.		130 (8 to 660)
Deer mouse	BEV	S.C.		$>1.3 \times 10^4$
Pinyon mouse	Borg	S.C.	1×10^3 (4.4×10^2 to 2.4×10^3)	
Pinyon mouse	6BC	S.C.	72 (50 to 103)	1.1×10^3 (8×10^2 to 1.6×10^3)
Grasshopper mouse	Borg	S.C.**		
Desert wood rat	6BC	S.C.	4.7×10^4 (1.9×10^4 to 1.2×10^5)	7.6×10^5 (3.0×10^5 to 1.9×10^6)
Harvest mouse	6BC	S.C.	$>2 \times 10^5$	$>3.2 \times 10^6$
Montane vole	6BC	S.C.	$>2 \times 10^3$	$>3.2 \times 10^4$
Ord kangaroo rat	6BC	S.C.	76 (42 to 137)	1.2×10^3 (6.7×10^2 to 2.2×10^3)
Ord kangaroo rat	NJT	S.C.	$>4.6 \times 10^6$	$>5.2 \times 10^5$

* Results of two experiments.

** Anticomplementary activity of serum interfered with CF antibody titration to the extent that an ID_{50} dose could not be determined.

Deer mice were observed to be resistant to lethal infection with the BEV strain of Bedsoniae, by all three routes.

Bacteremia development and persistence:

Rodents - Guinea pigs and normal deer mice were tested for the development and persistence of bacteremia following the inoculation of 6BC and NJT strains of bedsonia. Naked strain deer mice and desert wood rats were also tested following inoculation of strains of NJT and 6BC, respectively (Table 13). In all experiments, bedsonia were recovered from the blood of these animals by the first or second day. Isolations were usually then made daily through the third to seventh day. There was not a great difference in the persistence of the two different strains in the blood of the animals tested. Persistence of the NJT strain in the blood of the guinea pigs was one to two days longer then 10^6 organisms rather than 10^5 were inoculated.

TABLE 13. Bacteremia development and persistence in rodents following the inoculation of Bedsoniae group organisms

Rodents	Strain	$MICLD_{50}$ Dose and route	Passages in white mice	Days after inoculation* 1	2	3	4	5	6	7	8	9
Guinea pig	6BC	$2x10^6$ I.P.	1st	-	-	-	-	+	-	-		-
			2nd	-	-	+	+		+	-		-
			3rd		+					+		
Guinea pig	NJT	$4.6x10^6$ I.P.	1st	+	-	-	-	+	-	-		-
			2nd		-	-	-		-	-		-
			3rd		+	-	+		-	-		-
Guinea pig	NJT	$4.6x10^6$ I.P.	1st	+		-		-		-		-
			2nd	+		+		-		-		-
			3rd			+		-		-		-
Deer mice, naked	NJT	$4.6x10^6$ I.P.	1st	-	+	-	-	-	-	-		-
			2nd	-		-	-	-	-	-		-
			3rd	-		+	+		-	-		
Deer mice, normal	NJT	$1.8x10^5$ S.C.	1st	-	-		-	-		-		
			2nd	+	+		+	-		-		
			3rd					-		-		
Deer mice, normal	6BC	$8x10^5$ S.C.	1st		-		-	-		-		
			2nd		+		+	-		-		
			3rd				+					
Desert wood rat	6BC	$8x10^5$ I.P.	1st	-	+	+	+	-	+	-		
			2nd	+		+		+		-		
			3rd							+		
Guinea pig	NJT	$4.6x10^6$ I.P.	One passage in eggs	-	+	+	+	+	-	-		

* In each study with guinea pigs the blood of the same five guinea pigs was pooled and tested at each interval. Five wild rodents were sacrificed and their blood pooled at each interval.

Complement-fixing antibody response:

Rodents - Development and persistence of psittacosis CF antibody in deer mice, desert wood rats, and guinea pigs following inoculation of 10^4 to 10^6 $MICLD_{50}$ doses of bedsonia has been summarized in Tables 14 through 19. It is readily apparent from these tables that these rodents do not form high CF titer antibody when inoculated with high doses of virulent bedsonia. When antibody was formed, it disappeared rapidly.

TABLE 14. Psittacosis complement-fixing antibody titers of desert wood rats following subcutaneous inoculation of $2x10^6$ $MICLD_{50}$ doses of strain 6BC.

Weeks after inoculation	Wood rat numbers*, **				
	1	2	3	4	5
0	<16	<16	<16	<16	<16
1	<16	<16	<16	<16	<16
2	<16	<16	<16	<16	<16
3	<16	<16	<16	<16	<16
4	<16	<16	64	16	16
5	<16	<16	32	16	<16
6	<16	<16	32	<16	Died
8	<16	<16	<16	<16	
10	<16	<16	<16	<16	

* Five individual rats were bled repeatedly for sera.
** Reciprocal of serum titer

TABLE 15. Psittacosis complement-fixing titers of desert wood rats following subcutaneous inoculation of $3.5x10^6$ $MICLD_{50}$ doses of strain NJT.

Weeks after inoculation	Wood rat numbers*, **				
	1	2	3	4	5
0	<16	<16	<16	<16	<16
1	<16	16	<16	<16	<16
2	<16	32	<16	<16	<16
3	<16	32	<16	<16	<16
4	<16	64	<16	<16	<16
5	<16	16	16	<16	<16
6	<16	16	<16	<16	<16
8	<16	<16	<16	<16	<16
10	<16	<16	<16	<16	<16

* Five individual rats were bled for sera.
** Reciprocal of serum titer.

TABLE 16. Psittacosis complement-fixing antibody titers of deer mice following subcutaneous inoculation of $2x10^4$ $MICLD_{50}$ doses of strain 6BC

Weeks after inoculation	Deer mouse number *, **				
	1	2	3	4	5
0	<16	<16	<16	<16	<16
1	<16	<16	<16	<16	<16
2	64	<16	<16	<16	<16
3	<16	<16	<16	<16	<16
4	<16	<16	<16	<16	<16
5	<16	<16	<16	<16	<16
6	16	<16	<16	<16	<16
8	<16	<16	<16	<16	<16

* Five individual rats were bled repeatedly for sera.
**Reciprocal of serum titer.

TABLE 17. Psittacosis complement-fixing antibody titers of desert wood rats following subcutaneous inoculation of $2x10^4$ $MICLD_{50}$ doses of strain 6BC

Weeks after inoculation	Wood rat number *, **				
	1	2	3	4	5
0	<16	<16	<16	<16	<16
1	<16	<16	<16	<16	<16
2	64	<16	<16	<16	<16
3	<16	<16	<16	<16	<16
4	<16	<16	<16	<16	<16
5	<16	<16	<16	<16	<16
6	16	<16	<16	<16	<16
8	<16	<16	<16	<16	<16

* Five individual rats were bled repeatedly for sera.
** Reciprocal of serum titer.

TABLE 18. Psittacosis complement-fixing antibody titers of guinea pigs following intraperitoneal inoculation of $4.5x10^6$ $MICLD_{50}$doses of NJT

Weeks after inoculation	Guinea pig number *, **						
	1	2	3	4	5	6	7
0	<16	<16	<16	<16	<16	<16	<16
2	<16	64	<16	<16	16	<16	<16
3	<16	<16	<16	64	32	<16	<16
4	15	<16	16	32	<16	<16	<16
5	16	32	16	<16	<16	16	<16

* Seven individual guinea pigs were bled repeatedly for sera.
** Reciprocal of serum titer.

TABLE 19. Psittacosis complement-fixing antibody titers of guinea pigs following intraperitoneal inoculation of $2x10^6$ MICLD50 doses of strain 6BC

Weeks after inoculation	Guinea pig number *, **							
	8	9	10	11	12	13	14	15
0	<16	<16	<10	<16	<16	<16	<16	<16
2	<16	<16	<16	16	<16	<16	<16	32
3	16	<16	<16	<16	<16	<16	<16	<16
4	<16	<16	<16	<16	<16	<16	<16	<16
5	<16	<16	<16	16	16	<16	<16	<16
6	32	<16	<16	<16	<16	<16	<16	<16

* Eight individual guinea pigs were bled repeatedly for sera.
** Reciprocal of serum titer.

Discussion:

Rodents - Extensive studies of natural infections of birds, livestock, and poultry with bedsonia group organisms and experimental infection studies in laboratory animals with these agents have been published by many workers. Since such data are not of direct importance to our present discussion, and since these topics have been reviewed in detail elsewhere, (Sidwell et al.,[20] Meyer,[21]) we will not discuss such aspects here.

Compared to the volume of work reviewed in the references cited above, very little has been published concerning the interrelationships of the bedsonia group and wildlife. Strains of bedsonia have been isolated from the opossum (Roca-Garcia);[22] and the ferret (Francis and Magill).[23] Several species of wildlife native to the Great Basin area have been found to contain antibody that would fix complement in the presence of psittacosis antigen (Stoenner et al.;[3] Ecol. Rept. No. 103;[18] and the PA(b) section of this report.[24]).

Experimentally, the pocket gopher, Thomomys bottae bottae, has been observed to be lethally susceptible to infection by several routes of infection (Hoge;[25] Lillie and Hoge[26]). Cotton rats, Sigmondon sp., were also lethally susceptible to infection with the Louisiana strain of bedsonia by several routes of inoculation (Meyer).[21] Ground squirrels, presumably Citellus sp.) have been reported to be fatally infected with bedsonia inoculated by the intranasal and intracranial routes, whereas wild rats (presumably Rattus species), and deer mice, were resistant to infection, (Meyer).[21] Other workers have reported that the ground squirrel, Citellus beecheyi beecheyi (Richardson), as well as the wild rat, Rattus norvegicus, could not be infected with bedsonia (Hoge).[25]

Russian workers have demonstrated that Microtus arvalis, Mus musculus, Citellus undulatus, Cricetalus triton, and Cr. auratus, were susceptible to infection (Terskikht et al.)[27] These workers also reported the Apodemus agrarius and Neskia indica were not susceptible to infection.

Seven species of mice were tested and observed to be resistant to lethal infection with one to five different strains of bedsonia inoculated subcutaneously. Deer mice were also resistant to lethal infection with four strains of bedsonia inoculated by the IC and IP routes. Many of these animals, however, were infected by the doses of organisms inoculated, as was indicated by development of CF antibody.

Ord kangaroo rats were susceptible to 10^6 $MICLD_{50s}$ of strain 6BC, but resistant to 10^6 $MICLD_{50s}$ of strain NJT by the SC route. The pinyon mouse and Ord kangaroo rat were significantly more susceptible by the SC route with the 6BC strain than were all other rodents tested. Deer mice were significantly more susceptible to SC infection with the Borg strain than were the pinyon mice. Deer mice were more susceptible to IC inoculation of BEV strain than by other routes, but were more susceptible to IP inoculation of strain 6BC than by other routes, and resistant to NJT inoculated by all three routes.

It is readily apparent from a study of Table 12 that there is a marked variation in susceptibility of rodents to bedsonia, and that within species the susceptibility is dependent on the strain of organism and the route of inoculation.

Studies of bacteremia in deer mice, desert wood rats, and guinea pigs indicate that all these animals may be infected by high doses (10^5 to 10^6 $MICLD_{50s}$) of bedsonia by the IP or SC routes. Additional studies of the viremia in animals may be used as an indication of the degree of susceptibility to the infection.

By observing the results of studies on the development and persistence of CF antibody in infected rodents summarized in Tables 14 through 19, it is apparent that the rodents tested are poor producers of the antibody. The development and persistence of antibody in the guinea pigs was very irregular, with titers fluctuating from week to week. The poor responses summarized in Tables 16 and 17 in deer mice and wood rats were due to the low dose of organism inoculated in relation to the rodents' susceptibility to infection. Some wood rats infected by the inoculation of higher doses of bedsonia (Tables 14 and 15), did develop persisting antibody. The antibody produced in wood rats was much more stable than was that produced in the guinea pigs. The dose of bedsonia of both strains inoculated into guinea pigs was an infective dose based on the observations of the development of a viremia following the inoculation of organisms (Table 13).

Plague (Pasteurella pestis)

Host susceptibility:

Aves - Domestic pigeons have been tested for their susceptibility to infection with graded doses of P. pestis, Alexander strain. They were resistant to subcutaneous inoculation of doses up to and including 9.4×10^7 viable cells. None of the pigeons developed symptons of infection, or CF antibody to the Fraction I antigen of P. pestis. Those inoculated with 9.4 by 10^7 cells were bled weekly for six weeks. None developed CF antibody.

Two sparrow hawks were each fed one R. exulans, dead of P. pestis infection. Both hawks ate the entire carcases, about 35 to 40 grams each. They survived without symptoms of infection, and neither developed CF antibody against the Fraction I antigen.

Rodents - *Polynesian rats were tested for* susceptibility to infection by the SC route with the Alexander strain of P. pestis. The LD_{50} was 170 (38 to 770) viable cells and the ID_{50} was 66 (14 to 310) viable cells. The average day of death and the mortality ratio at each dosage are summarized in Table 20.

Discussion:

Aves - In the extensive review of the literature (Pollitzer)[28] reported that birds in general are resistant to infection with P. pestis. Starving pigeons, however, were found to be susceptible to infection, as were some birds given massive doses of the bacillus by the intravenous and intraperitoneal routes. Young chicks of domestic chickens were susceptible. Our observations on the resistance of pigeons agrees with previously published works of others. Pollitzer makes no reference to studies of antibody formation in experimentally inoculated birds. We were unable to demonstrate the presence of CF antibody in pigeons given up to 10^7 P. pestis organisms.

"Casts" of birds of prey, containing the undigested remains of rodents infected with P. pestis have been found to contain viable organisms, even though the birds were resistant to infection with P. pestis. Such "casts" may be eaten by rodents and result in a source of infection (Pollitzer).[29] We did not test the "casts" of the sparrow hawks for viable cells, but the birds showed no signs of infection. According to the published literature the "casts" from these birds were probably infected and could have been a source of organisms for rodents to become infected.

Rodents - In the orient, R. exulans is frequently a host of P. pestis (Pollitzer).[29] This animal is abundant throughout parts of the orient and the islands of the southern Pacific ocean. This rat's susceptibility to P. pestis infection was similar to that of the montane vole and the laboratory guinea pig.

TABLE 20. Susceptibility of the polynesian rat to subcutaneous infection with Pasteurella pestis, Alexander strain.

Viable cells inoculated	Mortality ratio	Average day of death
6.6×10^{7}	6/6	2.2
6.6×10^{6}	6/6	2.6
6.6×10^{5}	6/6	3.2
6.6×10^{4}	6/6	5.2
6.6×10^{3}	0/6	
6.6×10^{2}	3/6	9.7
6.6×10^{1}	4/6	5.8
6.6×10^{0}	4/6	8.8
6.6×10^{-1}	0/6	
6.6×10^{-2}	0/6	

Vector Transmission Studies

Rocky Mountain spotted fever:

When it became apparent that the use of Bldg. 4218 was to be delayed, ticks of the species Ornithodoros sparnus and O. parkeri were fed on guinea pigs in Bldg. 3204 at GPI-1. These ticks had been fed once on an artificial membrane and in most cases had not fed well enough to maintain them for any length of time. Two of the six on which O. parkeri were fed developed symptoms developed in the pigs on which O. sparnus were fed.

Adult and first stage nymphal O. sparnus were fed on febrile guinea pigs which had been inoculated with R. rickettsii. Subsequently both groups were fed on susceptible guinea pigs, which failed to develop symptoms of spotted fever and on challenge with the organism were found to have no immunity, indicating that the ticks had not transmitted the disease. Samples of the ticks were then tested by inoculation into guinea pigs and were found to be still harboring R. rickettsii. Part of each lot have died. Ecdysis was several weeks slower than in control ticks. Only one female has laid eggs, and only one of these has hatched.

A rabbit on which several Otobius lagophilus were feeding was inoculated with R. rickettsii. After the first one or two ticks had finished engorging and had disengaged, the remaining 8 ticks were removed. Seven were put aside in a desiccator jar for ecdysis and egg laying, to test wheter or not R. rickettsii would be transmitted to the new generation by females. None of these ticks molted and all died within three weeks. Control ticks molted normally, mated, and produced viable eggs.

Living lice of the species Fahrenholzia reducta, a specific parasite of Perognathus formosus, were collected from a number of fairly heavily infested individuals of this species, and placed on four others. The latter were then inoculated with R. rickettsii. At the death of one of the mice from spotted

fever, all of the lice from all of the mice were collected and thirty were placed on one healthy mouse whose own lice had been removed. No transmission of the disease occurred.

Six Ord kangaroo rats which were infested with Dermacentor parumapertus ticks were inoculated with R. rickettsii. Within two days engorged nymphs began disengaging from the rats. A total of 176 were collected and within 21 days 29 of these had died. None had molted. By the same time about 46% of the control ticks had molted to adults. If these nymphs molt, part of them will be tested by animal inoculation for survival of the organism, the remaining adults will be fed on healthy rabbits in attempts at transmission, both by biting and through eggs, to the next generation of ticks.

One of the above rats was harboring a nearly engorged female Ixodes kingi. This tick is being held for egg laying and for possible transovarial transmission trials.

Psittacosis:

Four Neotoma lepida were each infected with an estimated 200 larval O. sparnus. Three of the four were then inoculated with a strain of psittacosis agent. As the larvae become engorged they are being collected. Samples will be inoculated into embryonated eggs and into white mice, to determine whether or not infection has occurred. In the event the ticks have become infected, attempts will be made to transmit the organism to healthy animals.

Engorgement has been slower on the infected rats than on the healthy ones. But molting time of the larvae is about the same as for the ticks from the control rat. The infected rats were less active than the control, and so removed fewer ticks by grooming. Only about 21% of the ticks were recovered from the control rats, as compared to about 95% from one of the infected ones.

Laboratory Diagnostic Studies

ES and BA Phases:

During the report period, 4157 wild animal specimens and their ectoparasites were examined in the Epizoology Laboratory. Standard and accepted isolation and serological procedures (1-5) were used to determine the incidence of Brucella species, Pasteurella tularensis, P. pestis, Bacillus anthracis, Coxiella burnetii, R. rickettsii, and the psittacosis-lymphogranuloma group of organisms. Serum samples from the same specimens were examined, using the complement fixation (CF) test for P. pestis, C. burnetii, R. rickettsii, and the psittacosis group; while the tube agglutination test was used to detect P. tularensis and Brucella antibodies. Modifications of laboratory procedures instituted during the year are discussed in a separate section of this report and with each organism.

In addition to the wildlife specimens mentioned above, 681 domestic animal serum samples were examined serologically in the same manner as described for wildlife sera, as were indicator guinea pig sera from 458 ectoparasite pools, 1067 tissue pools, 310 retest pools and 147 saline controls (Table 21).

A breakdown of the total serology accomplished in the Epizoology Laboratory during the period is shown in the same table. It will be noted that most samples were examined for six different antibodies. In addition to the routine serological tests mentioned above, several other tests, using different antigens and techniques, were also performed on many of the serum samples. It is estimated that approximately 100,000 individual serological tests were made.

A breakdown of the wildlife samples tested by species and area is shown in Tables 42, 43 and 44. Nineteen species of rodents, 3 species of lagomorphs, 59 species of birds and 20 species of other vertebrates were examined. The domestic animals consisted entirely of cattle and sheep.

TABLE 21. Carcass and serum specimens received for examination by the Epizoology Laboratory during 1963.

Disease survey animals (rodents)		2923*
Disease survey animals (lagomorphs)		573*
Disease survey animals (other vertebrates)		54*
Disease survey animals (birds)		606*
Disease survey animals (domestic livestock)		681*
Disease survey animals (domestic livestock, 1962)		522*
Guinea pig (tissue challenge)	(1067)	2034*
Guinea pig (ectoparasite challenge)	(458)	916*
Guinea pig (retest challenge)	(310)	620*
Guinea pig (controls)		147*
Plague survey		1449
Special survey		1080
Experimental sera		5730
Miscellaneous serum samples		890
"Micro-titer" retest of serum samples (1960-1963)		2050
	Total specimens	20,275
Minimum number of serological tests actually performed		76,950*
Estimated number of serological tests actually performed		100,000

Number of different species examined:	
Rodents	19
Lagomorphs	3
Birds	59
Others	20
Total different species	101

Different serological tests performed:	
Complement fixation	11
Agglutination (slide and tube)	8
Others	4
Total different tests	23

* Examined routinely for at least six different antibodies.
** Does not include retests of positives or controls.

Brucella species (brucellosis):

Two isolations of Brucella neotomae were made from the tissues of wood rats collected at North Skull Valley and Gold Hill (Table 22). This is the first evidence of the Brucella species in North Skull Valley and the isolation of this species since 1962 (Ecol. Rept. No. 70).[10]

Brucella agglutinins were found in the sera of 33 wildlife specimens, involving nine different species. These were jack rabbits, 20; deer mice, 4; mule deer, 3; and one each of the following: Nuttall cottontail, Audubon cottontail, long-tailed pocket mouse, Great Basin pocket mouse, harvest mouse; and the wood rat from which organisms were isolated (Table 22).

This is the first year that cottontails, mule deer, pocket mice, and harvest mice have been Brucella seropositive in this survey, although they have been implicated with Brucella infections elsewhere. The areas from which positive specimens were taken include Gold Hill, Wig Mountain, Trout Creek, Deep Creek, Granite Mountain, Little Davis Mountain, Roosevelt, Logan, South Wendover, West Wendover, South Skull Valley, Montello, Grouse Creek, Dugway Mountain, Dugway Valley, Test Grids, Camelback, Fish Springs, and Erickson Pass. The first four areas have yielded Brucella positives in previous years, the latter 15 have not, although most of them have been extensively trapped (Table 22). As noted in previous reports (Nos. 70 and 100),[10, 11] the increased number of specimens found to be Brucella positive indicates this bacterial genus is much more prevalent than formerly thought, with the probability of a recent spread of the organism (s) into new areas and new animal species.

The mechanisms of transmission of this bacterial genus in wildlife are unknown, but are probably principally by means of contaminated wastes from infected animals, or by cannibalism. Spread by arthropod vectors is also a distinct possibility although we have not recovered infected ectoparasites.

TABLE 22. Incidence of Brucella species in the wildlife specimens collected in western Utah, 1959-1963, determined by specific agglutinins and isolations.

Species	Host Number	Area	Year	Reciprocal of antibody titer
Peromyscus maniculatus	9E 51	Callao	1959	40
Neotoma lepida	9F 201	South Wendover	1959	-**
N. lepida	OF 1268	Trout Creek	1960	160
N. lepida	OF 1270	Trout Creek	1960	320
N. lepida	OF 1435	Trout Creek	1960	640**
Lepus californicus	OA 14	North Wig Mountain	1960	40
L. californicus	OA 21	North Wig Mountain	1960	40
L. californicus	OA 23	North Wig Mountain	1960	80
N. lepida	OE 836	Gold Hill	1960	40
L. californicus	1H 1306	Callao	1961	80
L. californicus	1H 1307	Callao	1961	40
L. californicus	1H 1308	Callao	1961	160
L. californicus	1E 514	Callao	1961	160
N. lepida	1G 1213	South Cedar Mountain	1961	1280
N. lepida	1J 1970	North Cedar Mountain	1961	320
Columba livia	1K 2156	Government Creek	1961	80
Citellus townsendii	2C 328	Government Creek	1962	40
N. lepida	2F 1218	Trout Creek	1962	640**
L. californicus	2G 1524	Government Creek	1962	80
L. californicus	2H 1740	South Skull Valley	1962	20
L. californicus	2H 1741	South Skull Valley	1962	80
L. californicus	2H 1821	Callao	1962	20
L. californicus	2H 1826	Callao	1962	40
L. californicus	2H 1827	Callao	1962	20
L. californicus	2H 1828	Callao	1962	40
Citellus leucurus	2I 1865	Wildcat Mountain	1962	20
L. californicus	2I 2057	West Wendover	1962	20
L. californicus	2J 2140	Johnson Pass	1962	80
L. californicus	2J 2141	Johnson Pass	1962	80
L. Californicus	2L 2835	Gandy	1962	20
P. maniculatus	3B 284	South Skull Valley	1963	20
Reithrodontomys megalotis	3B 287	South Skull Valley	1963	40
L. californicus	3B 250	Trout Creek	1963	20*
L. californicus	3B 258	Trout Creek	1963	20
L. californicus	3B 261	South Wendover	1963	20*
L. californicus	3B 262	South Wendover	1963	20
Perognathus parvus	3E 402	North Cedar Mountain	1963	40
N. lepida	3F 37	North Skull Valley	1963	**
L. californicus	3G 202	Camelback	1963	20*
L. californicus	3G 228	Little Davis Mountain	1963	20*

(continued)

TABLE 22. (continued)

Species	Host Number	Area	Year	Reciprocal of antibody titer
L. californicus	3G 232	Little Davis Mtn	1963	20
L. californicus	3G 701	Dugway Valley	1963	20*
L. californicus	3H 41	Test Grids	1963	20*
L. californicus	3H 53	Granite Mountain	1963	20*
Perognathus formosus	3H 270	Fish Springs	1963	40
N. lepida	3I 130	Gold Hill	1963	160**
Sylvilagus audubonii	3I 139	Deep Creek	1963	80
P. maniculatus	3I 494	West Wendover	1963	20
P. maniculatus	3I 498	West Wendover	1963	40
P. maniculatus	3I 511	West Wendover	1963	20*
L. californicus	3J 246	Wig Mountain	1963	20
L. californicus	3J 335	Erickson Pass	1963	80
S. nuttallii	3J 338	Erickson Pass	1963	40
L. californicus	3J 340	Dugway Mountain	1963	20*
L. californicus	3J 342	Dugway Mountain	1963	40
Odocoileus hemionus	3K 204	Roosevelt	1963	320
O. hemionus	3K 208	Logan	1963	320
O. hemionus	3K 209	Logan	1963	20
L. californicus	3K 276	Grouse Creek	1963	40
L. californicus	3K 295	Grouse Creek	1963	20*
L. californicus	3K 299	Grouse Creek	1963	20
L. californicus	3K 309	Montello	1963	20
L. californicus	3K 313	Montello	1963	40
L. californicus	3K 326	Montello	1963	20*

* Atypical reactions

** Brucella neotomae isolated from tissues

Most of the bird sera (70-90%) gave atypical reactions with Brucella antigen. These reactions were not the same as those listed in Table 22, and were considered negative. The agglutination consisted of a translucent semi-gel with large brown flocs and was usually evident to the 1:160 or greater dilution. It appears that the reaction is due to partial denaturation of the serum proteins. Extensive work will have to be done in order to effectively use the Brucella agglutination test with bird sera.

Thirty-four of 222 (15.2%) sera from cattle were reactive at dilutions of 1:40 or greater, while 51 of 458 (11.1%) sera from sheep were positive at the same dilutions (Table 23). The previous history of these animals is unavailable and the reactions may be attributable to previous immunizations in the case of the cattle. The cause of the agglutinins in sheep is not known at this time, but one species of this genus, Br. ovis, is known to be endemic in sheep in the western United States (McGowan and Schultz).[29] The degree of cross reactions to be expected in sera of livestock infected with different species of the genus Brucella is not known, but should be investigated. (We have demonstrated that an antigen prepared from each of the other Brucella species, including Br. neotomae, agglutinates in Br. abortus positive sheep sera, but not to the same extent as the homologous antigen). The susceptibility of sheep to Br. neotomae should also receive further attention.

The relative number of Brucella positive cattle sera is about the same as was found last year (Ecol. Rept. No. 100);[11] but was about half that found in previous years (Repts. Nos. 42 and 70).[30, 10] Sheep have not been tested in sufficient numbers during the past to make comparisons, but positive specimens have been found in those examined previously (Table 23A). Several sheep and cattle serum specimens were found to be reactive with both P. tularensis and Br. abortus antigens, but there was very little evidence of cross reactions, after being absorbed with the heterologous antigens.

TABLE 23. Incidence of Brucella abortus agglutinins in domestic livestock sera, 1963.

Zone and summer range	Specimens with titers of: 1:20	1:40	1:80	1:160	Total Pos.	Total tested
		CATTLE				
ZONE II						
Iosepa-Stansbury	1	6	0	0	7	30
ZONE III						
Callao	0	4	0	0	5	18
Erickson Pass (Delta)	0	0	1	1	1	11
ZONE IV						
Cedar Fort	2	2	3	1	8	37
Deep Creek Mtns. (Ibapah)	0	1	3	0	4	22
Lehi (Oquirrh Mtns.)	0	2	0	1	3	14
Benmore (Vernon)	9	7	2	0	18	91
Totals	12	22	9	3	46	223
		SHEEP				
Zone and winter range (Flock)						
ZONE II						
Condie (Hatch)	9	10	2	0	21	105
Dugway Mountains (Davis)	13	8	0	0	21	78
Iosepa (Deseret)	10	10	5	0	25	101
Dugway Mountains (Young)	3	3	2	0	8	48
Gold Hill (Aagard)	6	2	0	0	8	61
Iosepa-West Cedar Mtns. (Haynes)	7	3	0	0	10	65
Totals	42	36	9	0	93	458

TABLE 23A. Incidence of Br. abortus tube agglutinins in domestic livestock sera, 1957-1963

Year	Number positive 1:80 or greater	Total tested	Per cent positive
	CATTLE		
1957	15	176	8.5
1958	186	1964	9.5
1959	0	0	-
1960	43	338	12.7
1961	0	0	-
1962	18	240	7.5
1963	12	223	5.4
1964 (July)		72	
	1:40 or greater SHEEP		
1957	0	0	-
1958	22	196	11.2
1959	0	0	-
1960	1	1	100.0
1961	0	2	0
1962	2	2	100.0
1963	45	458	9.8
1964 (July)		801	

Pasteurella tularensis (tularemia)

Three strains of P. tularensis were isolated in 1963, two were from the tissues of jack rabbits collected at Camelback and Vernon; one was from the tissues of a desert cottontail collected at Grouse Creek (Table 24). The first two strains were found to be of maximum virulence for all common rodent and laboratory animal species, while the latter strain was found to be of reduced virulence (Table 25). The virulence of this latter strain of the organism appears to be an anomaly, as all previous strains isolated from rabbits and hares have been of maximum virulence,[10, 11] which is in accord with other findings (Jellison et al.).[31] The isolation of this strain corroborates an earlier conclusion[11] that low virulent strains are endemic to the desert region and provides a plausible explanation for many observations previously made in the survey, namely specific tularemia agglutinins in normally susceptible rodents and lagomorphs, and the occurrence of specific P. tularensis antibodies in tissue and ectoparasite injected guinea pigs. That this strain of P. tularensis was naturally of lesser virulence is indicated by the fact that the sera of this cottontail was found to have an agglutinin titer of 1:320, indicating an infection of some length of time. The induction of specific antibodies in the tissue injected guinea pigs caused several attempts to produce an infection in guinea pigs and mice from the stored tissues, but these were not successful. The organism was finally isolated from modified casein partial hydrolysate broth inoculated with tissues of mice after two blind three-day passages. This strain has not been changed in virulence after five consecutive passages each in mice, guinea pigs, rabbits, and deer mice.

TABLE 24. Incidence of P. tularensis in wildlife tissue specimens of Great Salt Lake Desert area, determined by isolation of the organism from tissue-injected guinea pigs, 1954-1963

Animal species	Host Number	Area	Date	Isolate Designation
			1954	
Lepus californicus	4G 19	Gold Hill	July	4G 19
			1955	
Lepus californicus	5E 791	Fish Springs	May	5E 791
L. californicus	5F 297,298	Callao	June	5F 297
			1956	
L. californicus	6C 187	North Skull Valley	March	6C 187
L. californicus	6H 16, 17	North Skull Valley	Aug.	6H 16
L. californicus	6C 185,185	North Skull Valley	March	6C 184
			1958	
Sylvilagus audubonii	-	South Skull Valley	June	SKV-1
L. californicus	-	South Skull Valley	June	SKV-2
L. californicus	-	South Skull Valley	June	SKV-3
L. californicus	8F 259,260	North Skull Valley	June	8F 260
			1961	
L. californicus	1H 1598	Grouse Creek	Aug.	1H 1598
L. californicus	1H 1599	Grouse Creek	Aug.	1H 1599
L. californicus	1H 1600	Grouse Creek	Aug.	1H 1600
L. californicus	1H 1601	Grouse Creek	Aug.	1H 1601
			1962	
Dipodomys ordii	2G 1460	GPI-3	July	2G 1460
Citellus leucurus	2G 1552,1553	Callao	July	2G 1552
			1963	
L. californicus	3D 132,133	Vernon	April	3D 132
S. audubonii	3E 766	Grouse Creek	May	3E 766*
L. californicus	3G 207	Camelback	July	3G 207

* Strain of reduced virulence.

TABLE 25. Virulence* studies of P. tularensis strain 3E 766, isolated from tissues of a cottontail, S. audubonii, from Grouse Creek, May, 1963.

Animal species	Number of Animals used	Approximate LD_{50} **
Mice		
Mus musculus	100	10^5
Deer mice		
Peromyscus maniculatus	100	10^6
Pinyon mice		
P. truei	100	10^6
Hamsters		
Cricetus auratus	20	10^6
Guinea pigs		
Cavia cobaya	50	10^8
Rabbits		
Oryctolagus cuniculus	5	$>10^{10}$
White rats		
Rattus rattus	10	$>10^{10}$

* Injected intraperitoneally. ** Reed and Muench method

As mentioned earlier, the findings of organisms in the tissues of an animal with an agglutination titer of 1:320 is unusual, but not impossible, as chronic tularemia has been demonstrated in our laboratory in other animal species with strains of lesser virulence. Of particular interest is the fact that such a strain of lesser virulence has been isolated from a rabbit, as the rabbit-hare-tick strains are generally (if not always) of maximum virulence (Jellison et al.).[31]

No isolations were made from the ectoparasites collected during this period, including those taken from the infected rabbit and hares discussed earlier.

Specific P. tularensis agglutinins were found in 15 specimens: seven mule deer, five from Callao and two from Roosevelt; one cottontail previously mentioned; one pinyon mouse from Erickson Pass; one jack rabbit from West Wendover one lynx from Camelback; one horned lark from Old River Bed; one duck, one magpie, and one prairie falcon, all from Callao. Each of these species except the lynx and the birds has been found to have tularemia agglutinins in the past (Table 26). All areas, except Old River Bed and Roosevelt (the latter was never previously trapped) have also been involved with seropositive specimens in previous years (Table 26).

A summary of the incidence of tularemia in the animal species during the last five years (as determined by all methods in the Disease Survey) is shown in Table 27. The incidence by area is shown in Table 28.

Agglutinin titers of 1:20 or greater were observed in 47 cattle and 93 sheep sera for a percentage of 21 and 20 respectively. The incidence of the antibodies in cattle and sheep from the different areas varied markedly, the percentage ranging from zero to almost 50% (Table 29).

TABLE 26. Incidence of Pasteurella tularensis infections in wildlife specimens collected from the Great Salt Lake Desert region, as determined by specific agglutinins in their sera, 1959-1963.

Animal species	Host No.	Area	Date	Titer*
			1959	
Peromyscus maniculatus	9A 7-8	Government Creek	June	80
Odocoileus hemionus	9A 112	Johnson Pass	Jan.	80
O. hemionus	9A 113	Johnson Pass	Jan.	80
Lepus californicus	9H 208	Callao	Aug.	40
P. maniculatus	9I 74	Johnson Pass	Sept.	160
P. maniculatus	9J 44	Government Creek	Oct.	40
Reithrodontomys megalotis	9J 45	Government Creek	Oct.	40
Taxidea taxus	9K 1	Little Davis Mtn.	Nov.	160
Eutamias minimus	9K 34	Vernon	Nov.	80
P. truei	9K 76	Lookout Pass	Nov.	40
P. maniculatus	9K 84	Lookout Pass	Nov.	40
P. truei	9K 86	Lookout Pass	Nov.	40
P. truei	9K 87	Lookout Pass	Nov.	40
			1960	
P. maniculatus	OD 272	Government Creek	April	40
Dipodomys microps	OG 1664	Camelback	July	20
			1961	
L. californicus	1H 1469	Callao	Aug.	40
L. californicus	1H 1687	West Wendover	Aug.	20
O. hemionus	1J 1980	Fountain Green	Oct.	80
O. hemionus	1J 1988	Callao	Oct.	40
O. hemionus	1J 1989	Callao	Oct.	20
O. hemionus	1J 1990	Callao	Oct.	40
O. hemionus	1J 1991	Callao	Oct.	160
O. hemionus	1J 1992	Callao	Oct.	40
			1962	
Citellus leucurus	2E 1070	Gold Hill	May	40
Canis latrans	2H 1742	S. Skull Valley	Aug.	320
O. hemionus	2J 2251	Callao	Oct.	40
T. taxus	2J 2306	Granite Mountain	Oct.	160
Eutamias dorsalis	2J 2343	S. Cedar Mtn.	Oct.	20
C. leucurus	2J 2406	Granite Mountain	Oct.	40
P. maniculatus	2J 2482	Johnson Pass	Oct.	40
			1963	
O. hemionus	3A 1	Callao	Jan.	40
O. hemionus	3A 2	Callao	Jan.	80
O. hemionus	3A 3	Callao	Jan.	20
O. hemionus	3A 4	Callao	Jan.	20
Lynx rufus	3A 39	Camelback	Jan.	40**
L. californicus	3E 753	West Wendover	May	40
Sylvilagus audubonii	3E 766	Grouse Creek	May	320
O. hemionus	3J 329	Callao	Oct.	20
P. truei	3J 395	Erickson Pass	Oct.	20
O. hemionus	3K 206	Roosevelt	Nov.	40
O. hemionus	3K 207	Roosevelt	Nov.	40
Pica pica***	3K 244	Callao	Nov.	20
Falco mexicanus***	3K 246	Callao	Nov.	20
Eremophila alpestris***	3C 120	Old River Bed	March	20
Anas platyrhynchos ***	3D 121	Callao	April	20

* Expressed as the reciprocal of the tube agglutination titer.
** Atypical agglutination *** Birds

TABLE 27. Incidence of tularemia infections in wildlife specimens of the Great Salt Lake Desert region, as determined by all methods 1959-1963, inclusive.

Species	1959		1960		1961		1962		1963	
	Pos/total	%	Pos/total	%	Pos/Total	%	Pos/total	%	Pos/total	%
RODENTS										
Citellus leucurus	1/236	0.4	0/245	-	1/202	0.5	3/151	2.0	0/195	-
C. townsendii	-	-	0/4	-	-	-	0/3	-	-	-
C. variegatus	-	-	0/3	-	-	-	0/2	-	-	-
Dipodomys microps	1/406	0.2	1/327	0.3	0/276	-	0/173	-	0/191	-
D. ordii	1/416	0.4	0/214	-	1/193	0.5	1/257	0.4	0/585	-
Erethizon dorsatum	0/1	-	-	-	-	-	-	-	-	-
Eutamias dorsalis	0/27	-	0/27	-	0/2	-	1/7	14.3	0/4	-
E. minimus	1/53	1.8	0/17	-	0/17	-	1/47	2.1	0/86	-
Microdipodops megacephalus	0/10	-	0/9	-	0/3	-	0/1	-	0/8	-
Microtus spp. (montanus)	0/4	-	0/2	-	0/7	-	0/2	-	0/16	-
Mus musculus	0/1	-	0/1	-	0/1	-	-	-	0/3	-
Neotoma cinerea	-	-	0/1	-	-	-	-	-	-	-
N. lepida	0/53	-	0/53	-	0/45	-	0/38	-	0/51	-
Ondatra zibethicus	0/1	-	-	-	0/4	-	-	-	0/2	-
Onychomys leucogaster	0/8	-	0/6	-	0/6	-	0/5	-	0/6	-
Perognathus formosus	0/65	-	0/110	-	0/86	-	0/96	-	0/143	-
P. longimembris	0/68	-	0/58	-	0/95	-	0/32	-	0/62	-
P. parvus	0/97	-	0/113	-	0/40	-	1/62	1.6	0/122	-
Peromyscus crinitus	0/75	-	0/24	-	0/41	-	0/25	-	0/24	-
P. maniculatus	4/957	0.4	1/499	0.2	0/453	-	1/1017	0.1	0/1249	-
P. truei	3/139	2.2	0/67	-	0/71	-	0/65	-	1/40	2.5
Rattus rattus	-	-	-	-	-	-	-	-	0/2	-
Reithrodontomys megalotis	1/102	1.0	1/44	2.3	0/43	-	1/84	1.2	0/134	-
LAGOMORPHS										
Lepus californicus	2/510	0.4	0/378	-	9/522	1.7	2/486	0.4	3/536	0.6
L. townsendii	-	-	-	-	0/2	-	-	-	-	-
Sylvilagus audubonii	0/26	-	1/40	2.5	0/30	-	0/25	-	1/16	6.2
S. nuttallii	0/4	-	0/1	-	0/2	-	-	-	0/19	-
OTHER VERTEBRATES										
Antilocapra americana	-	-	-	-	-	-	-	-	0/2	-
Odocoileus hemionus	2/15	13.3	0/17	-	6/19	31.6	1/21	4.8	7/41	17.1
Canis latrans	0/3	-	0/1	-	-	-	0/2	-	-	-
Felis catus	0/6	-	0/1	-	0/1	-	1/2	50.0	0/1	-
Lynx rufus	0/3	-	-	-	0/1	-	-	-	1/1	100.0
Spilogale gracilis	0/1	-	-	-	-	-	0/1	-	0/1	-
S. putorius	-	-	-	-	-	-	0/1	-	0/2	-
Taxidea taxus	1/4	25.0	-	-	-	-	1/1	100.0	0/1	-
Antrozous pallidus	-	-	-	--	-	-	0/1	-	-	-
Corynorhinchus rafinesquii	-	-	-	-	-	-	-	-	0/3	-
Myotis volans	-	-	-	-	-	-	-	-	0/1	-
Tadarida mexicana	-	-	-	--	-	-	-	-	0/1	-
Vulpes macrotis	0/1	-	0/2	-	-	-	0/2	-	0/3	-
AVES (all species)	0/16	-	0/1	-	0/11	-	4/243	1.6	4/606	0.7
Pica pica	-	-	-	-	-	-	-	-	1/1	100.0
Falco mexicanus	-	-	-	--	-	-	0/8	-	1/4	25.0
Eremophila alpestris	-	-	-	-	-	-	0/64	-	1/89	1.1
Anas platyrhynchos	-	-	-	--	-	-	-	-	1/4	25.0
Lanius ludovicianus	-	-	-	-	-	-	1/32	3.4	-	-
Melesgris gallopavo	-	-	-	-	-	-	3/27	11.1	-	-
TOTALS*	17/3292	0.1	4/2264	0.2	17/2164	0.8	14/2608	0.5	17/3551	0.36

* Totals do not include birds which were all tularemia negative except for the specimens shown in the Table. See Table 44 for the species examined during 1963.

TABLE 28. Distribution of tularemia according to area in Utah, as determined by all methods in wild mammals and birds.

Area	1959		1960		1961		1962		1963	
	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%
ZONE I										
Camelback	0/93	-	1/147	0.7	0/64	-	0/224	-	2/138	1.4
CD 22	0/20	-	0/67	-	-	-	-	-	-	-
Dugway Valley	1/51	2.0	0/30	-	0/40	-	0/32	-	0/110	-
Government Creek	3/454	0.7	1/54	1.9	1/124	0.8	2/273	0.7	0/240	-
GPI-3	-	-	0/117	-	0/50	-	1/26	3.8	0/112	-
Granite Mountain	0/35	-	0/48	-	0/27	-	2/111	1.8	0/104	-
Little Davis Mountain	1/122	0.8	0/60	-	0/137	-	2/262	0.4	0/151	-
North Wig Mountain	-	-	-	-	-	-	-	-	0/46	-
Old River Bed	1/288	0.3	0/60	-	1/30	3.3	0/66	-	1/146	0.7
Simpson Mountain	0/18	-	0/8	-	0/45	-	0/38	-	0/44	-
South Cedar Mountain	0/279	-	0/182	-	0/202	-	1/249	0.4	0/127	-
Test Grid	0/36	-	0/61	-	0/39	-	0/67	-	0/106	-
Wig Mountain	0/127	-	0/58	-	0/58	-	0/146	-	0/149	-
ZONE II										
Big Davis Mountain	-	-	-	-	-	-	-	-	0/60	-
Condie	-	-	-	-	-	-	-	-	0/82	-
Dugway Mountain	0/18	-	0/57	-	0/1	-	0/9	-	0/11	-
East Wendover	-	-	0/20	-	0/15	-	0/30	-	0/94	-
Erickson Pass	-	-	-	-	-	-	-	-	1/73	1.4
Fish Springs	0/43	-	1/73	1.4	0/112	-	0/170	-	0/106	-
Gold Hill	0/164	-	0/102	-	0/146	-	1/135	0.7	0/106	-
Iosepa	-	-	-	-	-	-	-	-	0/30	-
Johnson Pass	3/37	8.1	0/2	-	0/24	-	2/104	1.9	0/19	-
Lookout Pass	4/45	8.9	0/177	-	0/40	-	0/75	-	0/51	-
North Cedar Mountain	-	-	0/54	-	0/25	-	-	-	0/29	-
North Skull Valley	0/240	-	0/133	-	0/42	-	0/84	-	0/126	-
South Skull Valley	0/47	-	0/66	-	0/85	-	1/111	0.9	0/94	-
West Cedar Mountain	-	-	-	-	-	-	-	-	0/47	-
Wildcat Mountain	0/24	0	0/38	-	-	-	0/36	-	0/71	-
ZONE III										
Callao	1/367	0.8	0/152	-	7/315	2.2	2/265	0.8	8/217	3.7
Gandy	0/18	-	1/17	5.9	1/24	4.2	0/24	-	-	-
Grouse Creek	-	-	0/8	-	5/13	38.2	0/13	-	1/39	2.6
Lakeside	-	-	-	-	-	-	-	-	0/105	-
Lucin	-	-	0/4	-	0/10	-	0/5	-	0/2	-
Montello	-	-	0/7	-	0/3	-	0/7	-	0/53	-
North Wendover	0/196	-	0/72	-	0/49	-	0/28	-	0/96	-
South Wendover	0/104	-	0/13	-	0/45	-	0/25	-	0/99	-
Trout Creek	0/24	-	0/200	-	0/198	-	0/93	-	0/105	-
West Wendover	-	-	0/113	-	1/105	0.9	0/52	-	1/116	0.9
ZONE IV										
American Fork	-	-	-	-	-	-	-	-	0/21	-
Benmore	-	-	-	-	-	-	-	-	0/48	-
Clover	0/144	-	-	-	0/33	-	0/81	-	0/38	-
Deep Creek	0/1	-	0/48	-	0/27	-	0/31	-	0/103	-
Fountain Green	-	-	-	-	1/3	33.3	-	-	0/3	-
Midway	-	-	-	-	-	-	-	-	0/9	-
Orem	-	-	-	-	-	-	-	-	0/1	-
Payson	-	-	-	-	-	-	0/1	-	0/11	-
Saltair	-	-	-	-	-	-	-	-	0/108	-
Salt Lake City	-	-	-	-	-	-	-	-	0/15	-
Settlement Canyon	-	-	-	-	0/7	-	-	-	-	-
Stansbury	-	-	-	-	-	-	-	-	0/58	-
Utah Lake	-	-	-	-	-	-	-	-	0/63	-
Vernon	1/106	0.9	0/37	-	0/34	-	1/46	2.2	1/56	1.8
ZONE V										
Castle Rock	-	-	-	-	-	-	-	-	0/71	-
Cedar City	0/65	-	-	-	-	-	-	-	-	-
Cisco	-	-	-	-	-	-	-	-	0/5	-
Duchesne	0/38	-	-	-	-	-	-	-	0/30	-
Ferron	-	-	-	-	-	-	-	-	0/58	-
Fillmore	0/70	-	-	-	-	-	-	-	-	-
Hanksville	0/4	-	-	-	-	-	-	-	-	-
Kemmerer	-	-	-	-	-	-	-	-	0/16	-
Loa	-	-	-	-	-	-	-	-	0/30	-
Logan	-	-	0/80	-	-	-	3/27	11.1	0/4	-
Manti	-	-	-	-	-	-	0/4	-	-	-
Roosevelt	-	-	-	-	0/3	-	0/1	-	2/4	50.0
South Willow	0/30	-	-	-	-	-	-	-	-	-
TOTALS	15/3308	0.45	4/2265	0.18	17/2175	0.78	18/2851	0.6	17/4157	0.4

A sharp decrease in the percentages of seropositive cattle specimens was evident this year as compared to last year. This was true for the total samples examined, as well as those from specific areas, presumably from the same herds. For example in 1962, 25 of 40 cattle from Callao had agglutinins of 1:40 or greater,[10] while in 1963 none of 18 were positive at the same dilution.[11] From Ibapah (Deep Creek Mountains) 89 of 129 were positive at 1:40 or greater in 1962, while 9 of 22 were positive in 1963. The overall percentage of those positives at these dilutions for the two years was 61 and 11, respectively (Table 30). In order to verify these results, 100 serum samples from 1962 were retested simultaneously with 50 from 1963. The results obtained were comparable to those obtained in the original testing, indicating the results were valid. From the limited data available with these samples, a plausible explanation for this variation is not evident.

Cross reactions with Brucella antibodies were minimal as determined by extensive absorption studies conducted on the serum samples. The actual number of those positive for both tests was about what one would expect from the number of those positive with Brucella or Pasteurella antigen alone. This was true for both cattle and sheep.

TABLE 29. Incidence of Pasteurella tularensis agglutinins in domestic livestock sera, 1963.

Zone and summer range	Specimens with titers of: 1:20	1:40	1:80	1:160	Total Pos.	tested	% Pos.
			CATTLE				
ZONE II							
Iosepa-Stansbury (Skull Valley)	3	2	1	0	6	30	20
ZONE III							
Callao	1	0	0	0	1	18	5
Erickson Pass (Callao)	1	1	1	0	3	11	27
ZONE IV							
Cedar Fort	1	1	0	0	2	37	5
Deep Creek Mtns. (Ibapah)	3	6	0	0	9	22	40
Lehi (Oquirrh Mtns.)	0	1	0	0	1	14	7
Benmore (Vernon)	12	7	6	0	25	91	28
Totals	21	16	8	0	47	223	21
			SHEEP				
ZONE II							
Condie (Hatch)	15	40	8	4	46	105	44
Dugway Mtns. (Davis)	1	4	0	0	5	78	6
Iosepa (Deseret)	5	7	3	0	15	101	15
Dugway Mtns. (Young)	6	11	4	1	22	48	46
Gold Hill (Aagard)	0	0	0	0	0	61	0
Iosepa - West Cedar Mtns. (Haynes)	4	1	0	0	5	65	8
Totals	21	42	15	5	93	458	20

TABLE 30. Incidence of Pasteurella tularensis tube agglutinins in domestic livestock sera, 1957-1963

Year	Number positive (1:40 or greater)	Total tested	Per cent positive
	CATTLE		
1957	23	176	13
1958	467	1964	24
1959	0	0	0
1960	186	338	55
1961	0	0	0
1962	146	239	61
1963	24	223	11
	SHEEP		
1957	0	0	0
1958	not tested	196	-
1959	0	0	0
1960	1	1	100
1961	0	2	0
1962	1	2	50
1963	62	458	14
	SWINE		
1962	2	2	100

Pasteurella pestis (Plague):

There were no isolations of this organism from the tissues or the ectoparasites of the specimens collected for the disease survey. Five strains were isolated from tissues of specimens collected at Indian Farm Canyon. These were from a canyon mouse collected in January; and four deer mice, two collected in March, one in May and one in November. Virulence studies of the strains have not been completed as of this date. This makes a total of ten isolations from tissues and 43 isolations from fleas from this focus to date (Ecol. Rept. #100[11] Thorpe and Cavanaugh[32]).

Serological evidence of the disease was found in four disease survey serum samples: a jack rabbit taken at Montello in May (3E 747); two deer mice, one taken at Vernon in March (3C 46, and one collected at Clover in March (3C 70); and a muskrat collected at American Fork in March (3C 161). All specimens had CF antibody titers of 1:16 and were HA positive at greater than 1:40. Since this aspect (plague serology) of the disease survey was not routinely instituted until this year, these seropositive specimens are the first to be found, although seropositives have been found in Indian Farm Canyon.[32] Jack rabbits (Rust and Cavanaugh)[33] and deer mice, have been found to be naturally infected with the organism by others, so these findings are not unusual. As far as is known, however, this is the first evidence of plague in muskrats. Two muskrats examined were collected at the site of a reported tularemia epidemic in these animals.

These serological findings confirm and extend the observations made at Indian Farm Canyon,[11] that strains of lesser virulence are apparently widespread in nature in the western United States (Thorpe and Cavanaugh,[32] Rust and Cavanaugh[33]).

Bacillus anthracis (anthrax):

There was no evidence of B. anthracis in the tissues or the ectoparasites of the specimens examined during this period.

Rickettsia rickettsii (Rocky Mountain spotted fever):

No isolations of this organism were made from the tissue or the ectoparasite-infected guinea pigs. All suspect tissue and ectoparasite pools were injected into fertile eggs, in addition to pigs. Results obtained from these procedures were also negative. Antibody titers observed in the injected indicator guinea pigs, as well as those reported during the year of 1962,[10] were found not to be R. rickettsii specific antibodies, but nonspecific reactions with the soluble antigen used. These nonspecific RMsf antibody titers in guinea pigs have been discussed at length previously,[10] and will not be mentioned further, except to say that it has been found possible to eliminate almost completely all false positive RMsf reactions in the indicator guinea pig sera by using commercially available antigen at optimal dilutions. Similar results have been obtained with wildlife and domestic animal sera. These procedures are discussed in detail in another part of this report. All seropositive indicator guinea pigs reported for the previous year were also unable to be confirmed during this period upon retest of the original sera by other laboratories, as well as our own; and by reinjection of the stored tissue pools into fertile eggs and pre-bled negative guinea pigs.

Rocky Mountain spotted fever CF antibody titers of 1:16 or greater were found in 253 serum samples (Table 31). Four species, jack rabbits, deer mice, Ord kangaroo rats, and antelope ground squirrels accounted for nearly all of the seropositives, although Nuttall cottontails also exhibited an unusuallly high percentage. The harvest mouse and the chisel-toothed kangaroo rat were also involved.

Several new areas (Table 32) were found to yield RMsf serologically positive specimens this year, but these same areas were also trapped for the first time, so the meaning is insignificant. The relative percentages of positives in different areas remained fairly constant, except for Callao, which showed a marked decrease in positive samples. This can be explained in that the relative percentage of jack rabbits was much less in 1962 than in 1963, thus the figures are not indicative of a decrease of the disease in that area, but of a decrease in the number of a particular species trapped. In 1963, 5/18 rabbits collected from Callao were positive; in 1962 approximately 140 were collected, of which 70 were positive.

The serological findings are probably indicative of the actual disease incidence in all of the species mentioned, except in the case of deer mice. Many of these latter specimens give false positive reactions (that is they are positive at low titers with several different, unrelated CF antigens). These conclusions are substantiated by neutralization studies wherein the great majority of the jack rabbit, kangaroo rat, and ground squirrel serum samples provide protection to guinea pigs against challenge with R. rickettsii, but few of the deer mouse samples provide this protection. These neutralization experiments with deer mice are complicated by the fact that pools of serum must be used because of the small quantities of serum available after serological testing, and thus yield a higher percentage of apparent rather than actual positives.

None of the cattle sera were found to be RMsf positive. Fourteen sheep sera were found to have 1:16 titers, but all were also positive for psittacosis at the same titer, except for four from Deseret Livestock herds. Additional studies are anticipated to determine the significance of these cross reactions.

TABLE 31. Incidence of Rocky Mountain spotted fever in wildlife specimens of the Great Salt Lake Desert region, as determined by the complement fixation test.

Species	1959		1960		1961		1962		1963	
	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%
RODENTS										
Citellus leucurus	78/236	33.0	43/245	17.6	43/202	21.3	9/151	6.0	14/195	7.2
C. townsendii	-	-	0/4	-	-	-	0/3	-	-	-
C. variegatus	-	-	1/3	33.3	-	-	0/2	-	-	-
Dipodomys microps	88/406	21.6	53/327	15.9	22/276	8.0	11/173	6.4	1/191	0.5
D. ordii	83/416	19.9	35/214	16.4	23/193	11.9	3/257	1.2	22/585	3.8
Erethizon dorsatum	0/1	-	-	-	-	-	-	-	-	-
Eutamias dorsalis	7/27	25.9	0/27	-	0/2	-	0/7	-	0/4	-
E. minimus	3/53	5.6	1/17	5.9	2/17	11.8	1/47	2.1	0/86	-
Microdipodops megacephalus	1/10	10.0	0/9	-	0/3	-	0/1	-	0/8	-
Microtus spp. (montanus)	0/4	-	0/2	-	0/7	-	0/2	-	0/16	-
Mus musculus	0/1	-	1/1	100.0	0/1	-	-	-	0/3	-
Neotoma cinerea	-	-	0/1	-	-	-	-	-	-	-
N. lepida	16/53	20.1	7/53	13.2	6/45	13.3	0/38	-	0/51	-
Ondatra zibethicus	0/1	-	-	-	0/4	-	-	-	0/2	-
Onychomys leucogaster	0/8	-	0/6	-	2/6	33.3	2/5	40.0	0/6	-
Perognathus formosus	9/65	13.8	0/110	-	4/86	4.6	0/96	-	0/143	-
P. longimembris	5/68	7.3	4/58	6.9	4/95	4.2	0/32	-	0/62	-
P. parvus	14/97	14.4	3/113	2.6	7/40	17.5	8/62	12.9	0/122	-
Peromyscus crinitus	15/75	20.0	4/24	16.7	0/41	-	0/25	-	0/24	-
P. maniculatus	176/957	18.3	49/409	9.8	30/453	6.6	70/1017	6.9	69/1249	5.5
P. truei	28/139	14.7	2/67	3.0	3/71	4.2	1/65	1.5	0/40	-
Rattus rattus	-	-	-	-	-	-	-	-	0/2	-
Reithrodontomys megalotis	9/102	8.8	1/44	2.3	1/45	2.2	1/84	1.2	1/134	0.7
LAGOMORPHS										
Lepus californicus	269/510	52.7	153/378	40.5	221/522	42.3	170/486	35.0	143/536	26.7
L. townsendii	-	-	-	-	0/2	-	-	-	-	-
Sylvilagus audubonii	4/26	15.0	6/40	15.0	7/30	23.3	8/25	32.0	3/16	18.8
S. nuttallii	2/4	50.0	0/1	-	1/2	50.0	-	-	0/19	-
OTHER VERTEBRATES										
Antilocapra americana	-	-	-	-	-	-	-	-	0/2	-
Odocoileus hemionus	0/15	-	1/17	5.9	0/19	-	2/21	9.5	0/41	-
Canis latrans	1/3	33.3	0/1	-	-	-	0/2	-	-	-
Felis catus	0/6	-	0/1	-	0/1	-	0/2	-	0/1	-
Lynx rufus	0/3	-	-	-	0/1	-	-	-	0/1	-
Spilogale gracilis	0/1	-	-	-	-	-	0/1	-	0/1	-
S. putorius	-	-	-	-	-	-	-	-	0/2	-
Taxidea taxus	0/4	-	-	-	-	-	0/1	-	0/1	-
Antrozous pallidus	-	-	-	-	-	-	0/1	-	-	-
Corynorhinchus rafinesquii	-	-	-	-	-	-	-	-	0/3	-
Myotis volans	-	-	-	-	-	-	-	-	0/1	-
Tadarida mexicana	-	-	-	-	-	-	-	-	0/1	-
Vulpes macrotis	0/1	-	0/2	-	-	-	0/2	-	0/3	-
AVES (all species)	0/16	-	0/1	-	0/11	-	2/243	0.8	0/606	-
TOTALS	809/3292*	24.6	363/2264	16.1	376/2164	17.1	286/2608	11.0	253/3551	7.1

* Totals do not include birds which were all RMsf negative. See Table 44 for the species examined during 1963.

TABLE 32. Distribution of Rocky Mountain spotted fever in Utah, according to area, as determined by positive complement fixation antibody titers in wild mammals and birds during 1959 through 1963.

Area	1959		1960		1961		1962		1963	
	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%
ZONE I										
Camelback	1/93	1.0	16/147	10.9	4/64	6.3	15/224	6.7	16/138	11.6
CD 22	3/20	15.0	0/67	-	-	-	-	-	-	-
Dugway Valley	9/51	17.6	1/30	3.3	0/40	-	2/32	6.3	5/110	4.5
Government Creek	96/454	21.1	4/54	7.4	45/124	36.3	18/273	6.6	14/240	5.8
GPI-3	-	-	10/117	8.5	2/50	4.0	1/26	3.8	4/112	3.6
Granite Mountain	8/35	22.8	10/48	20.8	0/27	-	3/111	2.7	5/104	4.8
Little Davis Mountain	31/122	25.4	19/60	31.7	28/137	50.4	30/262	11.4	15/151	9.9
North Wig Mountain	-	-	-	-	-	-	-	-	1/46	2.2
Old River Bed	58/288	20.1	32/60	53.3	9/30	30.0	5/66	7.6	10/146	6.8
Simpson Mountain	3/18	16.6	2/8	25.0	5/45	11.1	2/38	5.3	6/44	13.6
South Cedar Mountain	44/279	15.7	15/182	8.2	11/202	5.4	26/249	10.5	9/127	7.1
Test Grid	2/36	5.5	3/61	4.9	0/39	-	6/67	8.9	6/106	5.7
Wig Mountain	52/127	40.9	23/58	39.7	11/58	19.0	21/146	14.4	11/149	7.4
ZONE II										
Big Davis Mountain	-	-	-	-	-	-	-	-	5/60	8.3
Condie	-	-	-	-	-	-	-	-	7/82	8.5
Dugway Mountain	5/18	27.7	17/57	29.8	0/1	-	1/9	11.1	10/1.3	8.8
East Wendover	-	-	2/20	10.0	0/15	-	0/30	-	6/94	6.4
Erickson Pass	-	-	-	-	-	-	-	-	6/73	8.2
Fish Springs	18/43	41.8	11/73	15.1	12/112	10.7	14/70	20.0	7/106	6.6
Gold Hill	95/164	57.9	13/102	12.7	25/146	17.1	16/135	14.9	5/106	4.7
Iosepa	-	-	-	-	-	-	-	-	1/30	3.3
Johnson Pass	5/37	13.5	1/2	50.0	0/24	-	2/104	1.9	5/19	26.3
Lookout Pass	13/45	28.8	3/77	3.9	0/40	-	1/75	1.3	2/51	3.9
North Cedar Mountain	-	-	1/54	1.9	2/25	8.0	-	-	0/29	-
North Skull Valley	78/240	32.5	25/133	18.8	3/42	7.1	9/84	10.7	12/126	9.5
South Skull Valley	12/47	25.5	18/66	27.2	22/85	25.9	6/111	5.4	9/94	9.6
West Cedar Mountain	-	-	-	-	-	-	-	-	0/47	-
Wildcat Mountain	0/24	-	3/38	7.9	-	-	0/36	-	4/71	5.6
ZONE III										
Callao	86/367	23.4	26/152	17.1	97/315	30.8	70/265	26.4	7/217	2.7
Gandy	4/18	22.2	0/17	-	14/24	58.3	2/24	8.3	-	-
Grouse Creek	-	-	6/8	75.0	4/13	30.8	5/13	38.5	5/39	12.8
Lakeside	-	-	-	-	-	-	-	-	0/105	-
Lucin	-	-	4/4	100.0	5/10	50.0	3/5	60.0	0/2	-
Montello	-	-	2/7	28.6	1/3	33.3	0/7	-	4/53	7.5
North Wendover	80/196	40.8	13/72	18.1	4/49	8.2	1/28	3.6	2/96	2.1
South Wendover	24/104	23.0	3/13	23.1	2/45	4.4	0/25	-	3/99	3.0
Trout Creek	7/24	29.1	46/200	23.0	48/198	24.2	7/93	7.5	4/105	3.8
West Wendover	-	-	19/113	16.8	13/105	12.4	8/52	15.4	10/114	8.8
ZONE IV										
American Fork	-	-	-	-	-	-	-	-	0/21	-
Benmore	-	-	-	-	-	-	-	-	2/48	4.2
Clover	24/144	16.6	-	-	0/33	-	7/81	8.6	5/38	13.2
Deep Creek	1/1	100.0	8/48	16.7	8/27	29.6	1/31	3.2	9/103	8.7
Fountain Green	-	-	-	-	0/3	-	-	-	0/3	-
Midway	-	-	-	-	-	-	-	-	1/9	11.1
Orem	-	-	-	-	-	-	-	-	0/1	-
Payson	-	-	-	-	-	-	0/1	-	0/11	-
Saltair	-	-	-	-	-	-	-	-	0/109	-
Salt Lake City	-	-	-	-	-	-	-	-	0/15	-
Settlement Canyon	-	-	-	-	0/7	-	-	-	-	-
Stansbury	-	-	-	-	-	-	-	-	9/58	15.5
Utah Lake	-	-	-	-	-	-	-	-	0/63	-
Vernon	7/106	6.6	4/37	10.8	1/34	2.9	6/46	13.0	9/56	16.1
ZONE V										
Castle Rock	-	-	-	-	-	-	-	-	1/71	1.4
Cedar City	18/65	27.6	-	-	-	-	-	-	-	-
Cisco	-	-	-	-	-	-	-	-	0/5	-
Duchesne	1/38	2.6	-	-	-	-	-	-	0/30	-
Ferron	-	-	-	-	-	-	-	-	1/58	1.7
Fillmore	11/70	15.7	-	-	-	-	-	-	-	-
Hanksville	0/4	-	-	-	-	-	-	-	-	-
Kemmerer	-	-	-	-	-	-	-	-	0/16	-
Loa	-	-	-	-	-	-	-	-	0/30	-
Logan	-	-	3/80	3.8	-	-	0/27	-	0/4	-
Manti	-	-	-	-	-	-	0/4	-	-	-
Roosevelt	-	-	-	-	0/3	-	0/1	-	0/4	-
South Willow	13/30	43.3	-	-	-	-	-	-	-	-
TOTALS	809/3308	24.4	363/2265	16.0	376/2175	17.3	288/2851	10.1	253/4157	6.1

Bird sera tested were all negative for the birds examined (Table 44).

During the ensuing year, additional work will be done in attempting to refine techniques for the isolation of agents of the Rickettsia genus, especially the strains of lesser virulence known to be endemic to this region. It is also anticipated that some special tick collecting will be done in the higher elevations so that Dermacentor andersoni can be processed in attempts to isolate some of the more virulent and classical strains of R. rickettsii.

Coxiella burnetii (Q fever):

Coxiella burnetii was isolated from the tissues of only one specimen, a chisel-toothed kangaroo rat collected in February from Dugway Valley, an area which did not yield a seropositive specimen. No isolations were made from ectoparasites during this report period.

The sharp decrease in number of isolations (20 in 1962, 1 in 1963), corresponds with the decrease in seropositives reported last year (227 or 8.7% in 1962, and 35 or 0.8% in 1963) (Tables 33 and 34). This decline can be attributed to the normal subsiding of the epizootic reported in 1960 (Ecol. Repts.),[34, 10, 35] and improved serological procedures which have eliminated many false positives and low titer multiple reactors which have been considered positive in previous years. Details concerning these changes and the comparable results obtained for different years are discussed elsewhere.

The Q fever disease picture (as determined by CF phase II antibodies) remained stable, both in animal species and the areas involved during this report period; that is, the relative percentage of positive specimens by area remained constant as compared to 1962, except for the overall drop in positive specimens mentioned in the preceding paragraph. As noted last year,[11] the relative number of D. microps involved was minimal, correlating very well

TABLE 33. Incidence of Q fever in wildlife specimens of the Great Salt Lake Desert region, as determined by complement fixation test, 1959-1963, inclusive.

Species	1959		1960		1961		1962		1963	
	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%
RODENTS										
Citellus leucurus	7/236	3.0	17/245	6.9	5/202	2.5	2/151	3.9	0/195	-
C. townsendii	-	-	0/4	-	-	-	0/3	-	-	-
C. variegatus	-	-	0/3	-	-	-	0/2	-	-	-
Dipodomys microps	22/406	5.4	122/327	37.3	54/276	19.6	5/173	2.9	0/191	-
D. ordii	30/416	7.2	37/214	17.3	19/193	9.8	5/257	1.9	3/585	0.5
Erethizon dorsatum	0/1	-	-	-	-	-	-	-	-	-
Eutamias dorsalis	1/27	3.7	1/27	3.7	0/2	-	0/7	-	0/4	-
E. minimus	0/53	-	0/17	-	0/17	-	0/47	-	0/86	-
Microdipodops megacephalus	0/10	-	0/9	-	0/3	-	0/1	-	0/8	-
Microtus spp. (*montanus*)	0/4	-	0/2		0/7	-	0/2	-	0/16	-
Mus musculus	0/1	-	1/1	100.0	0/1	-	-	-	0/3	-
Neotoma cinerea	-	-	0/1	-	-	-	-	-	-	-
N. lepida	5/53	9.4	15/53	28.2	10/45	22.2	0/38	-	2/51	3.9
Ondatra zibethicus	0/1	-	-	-	0/4	-	-	-	0/2	-
Onychomys leucogaster	1/8	12.5	1/6	16.7	2/6	33.3	2/5	40.0	0/6	-
Perognathus formosus	1/65	1.5	1/110	0.9	4/86	4.6	0/96	-	0/143	-
P. longimembris	1/68	1.4	8/58	13.8	8/95	8.4	2/32	6.3	0/62	-
P. parvus	15/97	15.4	10/113	8.8	7/40	17.5	4/62	6.5	0/122	-
Peromyscus crinitus	3/75	4.0	7/24	29.2	6/41	14.6	1/25	4.0	0/24	-
P. maniculatus	63/1957	6.5	126/499	25.3	54/453	11.9	811/1017	8.0	18/1249	1.4
P. truei	4/139	2.8	11/67	16.4	5/71	7.0	3/65	4.6	0/40	-
Rattus rattus	-	-	-	-	-	-	-	-	0/2	-
Thomomys bottae	-	-	1/1	100.0	-	-	-	-	-	-
Reithrodontomys megalotis	9/102	8.8	7/44	15.9	10/45	22.2	2/84	2.4	1/134	0.7
LAGOMORPHS										
Lepus californicus	57/510	11.1	154/378	40.7	119/522	22.8	104/486	21.4	7/536	1.3
L. townsendii	-	-	-	-	0/2	-	-	-	-	-
Sylvilagus audubonii	6/26	23.1	8/40	20.0	6/30	20.0	11/25	44.0	1/16	6.3
S. nuttallii	1/4	25.0	0/1	-	0/2	-	-	-	0/19	-
OTHER VERTEBRATES										
Antilocapra americana	-	-	-	-	-	-	-	-	0/2	-
Odocoileus hemionus	7/15	46.6	3/17	17.6	3/19	15.8	5/21	23.8	3/41	7.3
Canis latrans	0/3	-	0/1	-	-	-	0/2	-	-	-
Felis catus	0/6	-	0/1	-	0/1	-	0/2	-	0/1	-
Lynx rufus	0/3	-	-	-	0/1	-	-	-	0/1	-
Spilogale gracilis	0/1	-	-	-	-	-	0/1	-	0/1	-
S. putorius	-	-	-	-	-	-	-	-	0/2	-
Taxidea taxus	0/4	-	-	-	-	-	0/1	-	0/1	-
Antrozous pallidus	-	-	-	-	-	-	0/1	-	-	-
Corynorhinchus rafinesquii	-	-	-	-	-	-	-	-	0/3	-
Myotis volans	-	-	-	-	-	-	-	-	0/1	-
Tadarida mexicana	-	-	-	-	-	-	-	-	0/1	-
Vulpes macrotis	0/1	-	2/2	100.0	-	-	0/2	-	0/3	-
AVES (all species)	0/16	-	-	-	0/11	-	0/243	-	0/606	-
TOTALS*	233/3292	7.1	532/2265	23.5	312/2164	14.4	227/2608	8.7	35/3551	0.1

* Totals do not include birds which were all Q fever negative. See Table 44 for species of birds examined during 1963.

TABLE 34. Distribution of Q fever according to area in Utah, as determined by positive complement fixation antibody titers in wild mammals and birds, during 1959 through 1963.

	1959		1960		1961		1962		1963	
Area	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%	Pos/total	%
ZONE I										
Camelback	2/93	2.1	46/147	31.3	6/64	9.4	10/224	4.5	2/138	1.4
CD 22	1/20	5.0	15/67	22.4	-	-	-	-	-	-
Dugway Valley	2/51	3.9	6/30	20.0	1/40	2.5	1/32	3.1	0/110	-
Government Creek	18/454	4.0	7/54	12.9	18/124	14.5	12/273	4.4	2/240	0.8
GPI-3	-	-	27/117	23.1	5/50	10.0	1/26	3.8	3/112	2.7
Granite Mountain	0/35	-	10/48	20.8	0/27	-	5/111	4.5	2/104	1.9
Little Davis Mountain	9/122	7.3	20/60	33.3	15/137	10.9	25/262	9.6	1/151	0.7
North Wig Mountain	-	-	-	-	-	-	-	-	0/46	-
Old River Bed	7/288	2.4	27/60	45.0	5/30	16.7	0/66	-	0/146	-
Simpson Mountain	1/18	5.5	3/8	37.5	2/45	4.4	4/38	10.5	0/44	-
South Cedar Mountain	8/279	2.8	15/182	8.2	9/202	4.5	16/249	6.4	0/127	-
Test Grid	1/36	2.7	13/61	21.3	2/39	5.1	4/67	5.9	0/106	-
Wig Mountain	14/127	13.2	14/58	24.1	13/58	22.4	9/146	6.2	0/149	-
ZONE II										
Big Davis Mountain	-	-	-	-	-	-	-	-	1/60	1.7
Condie	-	-	-	-	-	-	-	-	1/82	1.2
Dugway Mountain	0/18	-	13/57	22.8	0/1	-	1/9	11.1	1/113	0.9
East Wendover	-	-	5/20	25.0	1/15	6.6	1/30	3.3	1/94	1.1
Erickson Pass	-	-	-	-	-	-	-	-	1/73	1.4
Fish Springs	11/43	25.5	20/73	27.4	16/112	14.3	3/70	4.3	0/106	-
Gold Hill	22/164	13.4	21/102	20.6	39/146	26.7	14/135	10.4	0/106	-
Iosepa	-	-	-	-	-	-	-	-	0/30	-
Johnson Pass	4/37	10.8	0/2	-	0/24	-	10/104	9.6	0/19	-
Lookout Pass	4/45	8.8	8/77	10.4	1/40	2.5	7/75	9.3	0/51	-
North Cedar Mountain	-	-	6/54	11.1	0/25	-	-	-	1/29	3.4
North Skull Valley	12/240	5.0	48/133	36.1	9/42	21.4	8/84	9.5	2/126	1.6
South Skull Valley	3/47	6.3	19/66	28.8	12/85	14.1	4/111	3.6	1/94	1.1
West Cedar Mountain	-	-	-	-	-	-	-	-	0/47	-
Wildcat Mountain	1/24	4.1	3/38	7.9	-	-	0/36	-	1/71	1.4
ZONE III										
Callao	33/367	9.8	34/152	22.3	75/315	23.8	60/265	22.6	6/217	2.8
Gandy	0/18	-	6/17	35.3	9/24	37.5	4/24	16.7	-	-
Grouse Creek	-	-	7/8	87.5	2/13	15.4	0/13	-	1/39	2.6
Lakeside	-	-	-	-	-	-	-	-	0/105	-
Lucin	-	-	4/4	100.0	0/10	-	1/5	20.0	0/2	-
Montello	-	-	3/7	42.8	0/3	-	0/7	-	0/53	-
North Wendover	35/196	17.8	5/72	6.9	0/49	-	1/28	3.6	2/96	2.1
South Wendover	17/104	16.3	2/13	15.4	3/45	6.8	1/25	4.0	0/99	-
Trout Creek	1/24	4.1	65/200	32.5	41/198	20.7	6/93	6.5	3/105	2.9
West Wendover	-	-	28/113	24.8	9/105	8.6	2/52	3.8	2/114	1.8
ZONE IV										
American Fork	-	-	-	-	-	-	-	-	0/21	-
Benmore	-	-	-	-	-	-	-	-	0/48	-
Clover	11/44	7.6	-	-	7/33	21.2	5/81	6.2	0/38	-
Deep Creek	1/1	100.0	17/48	35.4	9/27	33.3	2/31	6.5	0/103	-
Fountain Green	-	-	-	-	1/3	33.3	-	-	0/3	-
Midway	-	-	-	-	-	-	-	-	0/9	-
Orem	-	-	-	-	-	-	-	-	0/1	-
Payson	-	-	-	-	-	-	0/1	-	0/11	-
Saltair	-	-	-	-	-	-	-	-	0/109	-
Salt Lake City	-	-	-	-	-	-	-	-	0/15	-
Settlement Canyon	-	-	-	-	-	-	-	-	-	-
Stansbury	-	-	-	-	0/7	-	-	-	1/58	1.7
Utah Lake	-	-	-	-	-	-	-	-	0/63	-
Vernon	1/106	0.9	0/37	-	2/34	5.9	8/46	17.4	0/56	-
ZONE V										
Castle Rock	-	-	-	-	-	-	-	-	0/71	-
Cedar City	3/65	4.6	-	-	-	-	-	-	-	-
Cisco	-	-	-	-	-	-	-	-	0/5	-
Duchesne	3/38	7.9	-	-	-	-	-	-	0/30	-
Ferron	-	-	-	-	-	-	-	-	0/58	-
Fillmore	5/70	7.1	-	-	-	-	-	-	-	-
Hanksville	0/4	-	-	-	-	-	-	-	-	-
Kemmerer	-	-	-	-	-	-	-	-	0/16	-
Loa	-	-	-	-	-	-	-	-	0/30	-
Logan	-	-	15/80	18.8	-	-	0/27	-	0/4	
Manti	-	-	-	-	-	-	2/4	50.0	-	
Roosevelt	-	-	-	-	0/3	-	0/1	-	0/4	-
South Willow	3/30	10.0	-	-	-	-	-	-	-	-
TOTALS	233/3308	7.0	532/2265	23.5	312/2175	14.3	227/2851	8.0	35/4157	0.84

with the hypothesis that this species may be the principal reservoir and means of transmission of the organism during certain epizootics.[35]

All birds were negative for Q fever CF antibodies as has been found in previous years.

Q fever antibody titers (phase II) of 1:16 or greater were found in 26 of 458 sheep sera, for a percentage of 5.7%. As with tularemia agglutinins, the distribution of those CF titers was spotty, some flocks having a high incidence and some being negative. In 1959, the last year that an appreciable number of sheep were tested, none of 196 were Q fever seropositive (Table 35).

In contrast to the sheep, there were no cattle sera found to contain the phase II CF antibodies. These data are in agreement with the low number of seropositive cattle found in 1962 (12/247, for 4.9%).[11] This low infection rate of Q fever in cattle is very surprising in view of the incidence of the disease in these animals throughout Utah in previous years.[35] Several of the cattle and the negative sheep sera were examined, using phase I CF antigen and capillary tube agglutination antigen with uniformly negative results, corroborating the data obtained with Phase II antigen. It should be noted that many of these cattle are from areas yielding seropositive rodents during this and previous years (Table 34). The great majority of the cattle were grazed on the open range, putting them in close proximity with the rodent population. Many of the sheep flocks were wintered in areas yielding seropositive wildlife specimens and in the area yielding the only isolation (Dugway Valley). However, little correlation appears evident in the incidence of the disease in the two groups from these areas. The relationship between the two groups of animals in specific areas should become more apparent after next year's sampling. It is anticipated that the same flocks and areas will be sampled in 1964.

TABLE 35. Incidence of Q fever complement fixation antibodies in domestic livestock sera, 1963.

Zone and summer range	Specimens with titers of: 1:16	1:32	1:64	1:128	Total Pos.	tested
CATTLE						
ZONE II						
Iosepa-Stansbury (Skull Valley)	0	0	0	0	0	30
ZONE III						
Callao	0	0	0	0	0	18
Erickson Pass	0	0	0	0	0	11
ZONE IV						
Cedar Fort	0	0	0	0	0	37
Deep Creek Mtns. (Ibapah)	0	0	0	0	0	22
Lehi (Oquirrh Mtns.)	0	0	0	0	0	14
Benmore (Vernon)	0	0	0	0	0	91
Totals	0	0	0	0	0	223
SHEEP						
Zone and winter range (flock)						
ZONE II						
Condie (Hatch)	0	0	0	0	0	105
Dugway Mtns. (Davis)	1	0	0	0	1	78
Iosepa (Deseret)	0	0	0	0	0	101
Dugway Mtns. (Young)	8	2 (5)	0	0	10 (5)	48
Gold Hill (Aagard)	2	0	0	0	2	61
Iosepa-West Cedar Mtns. (Haynes)	13(1)	0 (1)	0	0	13 (2)	65
Totals	24(1)	2 (6)	0	0	26 (7)	458

Psittacosis - Lymphogranuloma group of organisms

No isolations of this group were made from the tissues or the ectoparasites from the specimens during 1963. Because of the prevalence of specific antibodies in apparently healthy guinea pigs, much extra work was expended to insure that viable organisms in the specimens were not the cause of these antibodies. These procedures included pre-bleeding and retesting of the sera of a majority of the indicator pigs (all after July, 1963); the reinjection of all tissues and ectoparasites into known negative indicator guinea pigs upon demonstrating a CF antibody titer difference of more than one tube when serologically positive animals were used as the initial indicator animals; and the injection of all suspect tissues and ectoparasites into white mice. When mice were used, two were sacrificed on the seventh day, and two were retained 28 days for serological studies. Because 40-70% of the normal guinea pigs weighing 350 grams or more were seropositive prior to injection, these procedures were necessary. Economics precluded use of only known negative indicator guinea pigs. In addition, all tissue and ectoparasite pools from the previous year that might possibly have induced psittacosis antibodies in the indicator guinea pigs were reexamined as described above. All were negative except the pigeon tissue previously reported as positive.[11]

Specific psittacosis antibodies had not been observed in normal guinea pigs in this laboratory prior to mid-1963, so these problems were not evident earlier. Extensive studies are underway to isolate the causative agents.

Twenty-one psittacosis CF positives were found in the wildlife serum specimens. The animals involved were nine jack rabbits; seven deer mice; three mule deer; one Audubon cottontail; and one grasshopper mouse (Table 36). Each of these species has been found serologically positive in previous years.

Areas involved were Camelback, South Cedar Mountain, Test Grids, Fish Springs, North Skull Valley, South Skull Valley, North Wendover, Trout Creek, and Deep Creek. New areas were Fish Springs, South Skull Valley, and Deep Creek (Table 37). This extension of the disease to additional areas in the survey should not necessarily be construed to represent a spread of the disease, but probably represents normal sampling procedures. Survey results to date indicate that detectable CF psittacosis antibodies may be naturally limited to selected animal species, but further sampling will be necessary to determine this.

Two bird specimens, a sharp-shinned hawk collected at Callao in November, and a seagull collected at Salt Lake City, were found to have a psittacosis serum titer of 1:64. These titers were not confirmed due to insufficient sera. However, they were single reactors among many negative specimens and thus must be provisionally accepted as positive (Table 36).

Forty-six cattle sera of the 222 tested had psittacosis antibody titers ranging from 1:16 to 1:64 (Table 38). Three of the herds, Callao, Erickson Pass and Lehi, from which a total of 43 specimens were sampled, were negative or had one positive, while those from Iosepa-Stansbury, Benmore Deep Creek Mountains, and Cedar Fort had 45 positives out of 180 specimens, indicating a considerable variance in herd infectivity. It is anticipated that additional sampling done during 1964 will help to resolve or verify these results. Over 50% of the sheep tested were seropositive (Table 38). All flocks had about the same incidence rate in contrast to the RMsf, Q fever and tularemia incidence rates discussed earlier. This high rate of infection is to be expected in view of the recently reported number of cases of psittacosis-lymphogranuloma caused infections in sheep in other parts of the state (Storz et al.)[36]

TABLE 36. Incidence of psittacosis infections in wildlife specimens of the Great Salt Lake Desert, determined by CF test, 1958, 1962-1963.

	1958		1962		1963	
Species	Pos/total	%	Pos/total	%	Pos/total	%
RODENTS						
Citellus leucurus	1/128	0.8	1/96	1.0	0/195	-
C. variegatus	-	-	1/1	100.0	-	-
Dipodomys microps	3/370	0.8	0/45	-	0/191	-
D. ordii	7/230	3.0	0/66	-	0/585	-
Eutamias dorsalis	0/5	-	0/3	-	0/4	-
E. minimus	0/13	-	0/27	-	0/86	-
Microdipodops megacephalus	0/5	-	0/1	-	0/8	-
Microtus sp. (*montanus*)	-	-	0/3	-	0/16	-
Mus musculus	0/4	-	-	-	0/3	-
Neotoma cinerea	0/1	-	-	-	-	-
N. lepida	5/65	7.7	0/12	-	0/51	-
Ondatra zibethicus	-	-	-	-	0/2	-
Onychomys leucogaster	1/4	25.0	1/3	33.3	1/6	16.7
Perognathus formosus	0/39	-	0/41	-	0/143	-
P. longimembris	0/15	-	0/18	-	0/62	-
P. parvus	0/39	-	0/23	-	0/122	-
Peromyscus crinitus	0/23	-	0/12	-	0/24	-
P. maniculatus	2/278	0.7	14/311	4.5	7/1249	0.5
P. truei	0/13	-	0/50	-	0/40	-
R. rattus	-	-	-	-	0/2	-
Reithrodontomys megalotis	1/33	3.2	0/43	-	0/134	-
Thomomys bottae	0/1	-	-	-	-	-
LAGOMORPHS						
Lepus californicus	4/101	4.0	5/149	3.4	9/536	1.7
Sylvilagus audubonii	0/6	-	1/5	20.0	1/16	6.7
S. nuttallii	-	-	-	-	0/19	-
OTHER VERTEBRATES						
Antilocapra americana	-	-	-	-	0/2	-
Odocoileus hemionus	-	-	1/17	5.9	3/41	7.3
Felis catus	-	-	1/1	100.0	0/1	-
Lynx rufus	-	-	-	-	0/1	-
Spilogale gracilis	-	-	0/1	-	0/1	-
S. putorius	-	-	-	-	0/2	-
Taxidea taxus	-	-	0/1	-	0/1	-
Corynorhinchus rafinesquii	-	-	-	-	0/3	-
Myotis volans	-	-	-	-	0/1	-
Tadarida mexicana	-	-	-	-	0/1	-
Vulpes macrotis	-	-	0/1	-	0/3	-
AVES						
Larus californicus	-	-	-	-	1/160	0.6
Columba livia	-	-	1/3	33.3	-	-
Accipiter striatus	-	-	-	-	1/1	100.0
Totals*	24/1374	1.75	25/930	2.6	22/3711	0.6

* Birds not included in totals which were all psittacosis negative except for three specimens shown in the table. See Table 44 for the species of birds examined during 1963.

TABLE 37. Distribution of psittacosis by area in Utah, as determined by positive complement fixation antibody titers in wild mammals and birds, 1958, 1962, and 1963.

Area	1958 Pos/Total	1958 %	1962 Pos/Total	1962 %	1963 Pos/Total	1963 %
ZONE I						
Camelback	2/68	2.9	1/60	1.7	1/138	0.7
CD 22	2/83	2.4	-	-	-	-
Dugway Valley	3/72	4.2	0/29	-	0/110	-
Government Creek	0/3	-	0/117	-	0/240	-
GPI-1	1/7	14.3	-	-	-	-
GPI-3	-	-	1/16	6.3	0/112	-
Granite Mountain	0/21	-	1/51	2.0	0/104	-
Little Davis Mountain	3/49	6.1	0/10	-	0/151	-
North Wig Mountain	-	-	-	-	0/46	-
Old River Bed	0/24	-	0/10	-	0/146	-
Simpson Mountain	0/10	-	2/38	5.3	0/44	-
South Cedar Mountain	5/148	3.4	3/66	4.5	1/127	0.8
Test Grid	1/98	1.0	1/22	4.5	2/106	1.9
Wig Mountain	0/11	-	1/50	2.0	0/149	-
ZONE II						
Big Davis Mountain	-	-	-	-	0/60	-
Condie	-	-	-	-	0/82	-
Dugway Mountain	-	-	-	-	0/113	-
East Wendover	-	-	1/30	3.3	0/94	-
Easy Area	0/4	-	-	-	-	-
Erickson Pass	-	-	-	-	0/73	-
Fish Springs	0/46	-	0/7	-	4/106	3.8
Gold Hill	1/132	0.8	-	-	1/106	0.9
Iosepa	-	-	-	-	0/30	-
Johnson Pass	-	-	1/73	1.4	0/19	-
Lookout Pass	-	-	2/78	2.6	0/51	-
North Cedar Mountain	-	-	-	-	0/29	-
North Skull Valley	2/88	2.3	-	-	1/126	0.8
South Skull Valley	-	-	0/19	-	1/94	1.1
West Cedar Mountain	-	-	-	-	0/47	-
Wildcat Mountain	-	-	1/35	2.9	0/71	-
ZONE III						
Callao	3/94	3.2	4/91	4.4	6/217	2.8
Gandy	-	-	1/13	7.7	-	-
Grouse Creek	-	-	0/14	-	0/39	-
Lakeside	-	-	-	-	0/105	-
Lucin	-	-	0/5	-	0/2	-
Montello	-	-	0/7	-	0/53	-
North Wendover	0/395	-	1/35	2.9	1/96	1.0
South Wendover	-	-	1/25	4.0	0/99	-
Trout Creek	1/12	8.3	-	-	1/105	1.0
West Wendover	-	-	1/52	1.9	1/114	0.9
ZONE IV						
American Fork	-	-	-	-	0/21	-
Benmore	-	-	-	-	0/48	-
Clover	-	-	0/27	-	0/38	-
Deep Creek	0/9	-	-	-	1/103	1.0
Fountain Green	-	-	-	-	0/3	-
Midway	-	-	-	-	0/9	-
Orem	-	-	-	-	0/1	-
Payson	-	-	0/1	-	0/11	-
Saltair	-	-	-	-	0/109	-
Salt Lake City	-	-	-	-	0/15	-
Stansbury	-	-	-	-	0/58	-
Utah Lake	-	-	-	-	0/63	-
Vernon	-	-	3/46	6.5	0/56	-
ZONE V						
Castle Rock	-	-	-	-	0/71	-
Cisco	-	-	-	-	0/5	-
Duchesne	-	-	-	-	0/30	-
Ferron	-	-	-	-	0/58	-
Kemmerer	-	-	-	-	0/16	-
Loa	-	-	-	-	0/30	-
Logan	-	-	0/27	-	0/4	-
Roosevelt	-	-	-	-	0/4	-
TOTALS	24/1374	1.7	26/1054	2.5	21/4157	0.5

TABLE 38. Incidence of psittacosis complement fixation antibodies in domestic livestock sera, 1963.

Zone and summer range	Specimens with titer of: 1:16	1:32	1:64	1:128	Total Pos.	Tested
CATTLE						
ZONE II						
Iosepa-Stansbury (Skull Valley)	3	3	0	0	6	30
ZONE III						
Callao	0	0	0	0	0	18
Erickson Pass (Delta)	0	0	0	0	0	11
ZONE IV						
Cedar Fort	5	2	2	0	8	37
Deep Creek Mtns. (Ibapah)	3	2	0	0	5	22
Lehi (Oquirrh Mtns.)	1	0	0	0	1	14
Benmore (Vernon)	17	7	1	0	25	91
Totals	29	14	3	0	46	223
SHEEP						
Zone and winter range (flock)						
ZONE II						
Condie (Hatch)	42	9	7	0	58	105
Dugway Mtns. (Davis)	32	2	13	1	48	78
Iosepa (Deseret)	46	8	4	2	60	101
Dugway Mtns. (Young)	13	2	0	0	15	48
Gold Hill (Aagard)	23	7	1	0	31	61
Iosepa-West Cedar Mtns. (Haynes)	21	6	0	0	37	65
Totals	177	34	25	3	239	458

ES Phase (Field Collection Procedures):

During this report period, the boundaries of several regular collecting areas were altered and the areas redesignated in what was considered a move to establish the collecting areas more on an ecological and geographical basis in accord with current concepts of landscape epizoology. Nine areas underwent elimination and consolidation. These were North Cedar Mountains, Johnson Pass, North Skull Valley, South Skull Valley, Simpson Mountain, Vernon, Lookout Pass, Clover, and North Wig Mountain. Seven newly designated areas arose from this revision: Condie, Iosepa, Big Davis Mountain, Erickson Pass, Stansbury, and West Cedar Mountains. Although the number of areas was reduced, the total sampling area was considerably increased. A total of 29 areas, covering 5,500 square miles, is now being systematically trapped for rodents. Lagomorphs are collected from all of these areas as well as from four additional areas. Since the effective date of the collecting area revision was 1 July, 1963, both old and new designations are used throughout this report. For comparison and orientation purposes, Fig. 1 is included to show the old collecting areas, whereas Fig. 2 shows the location of the present collecting areas and their relation to each other.

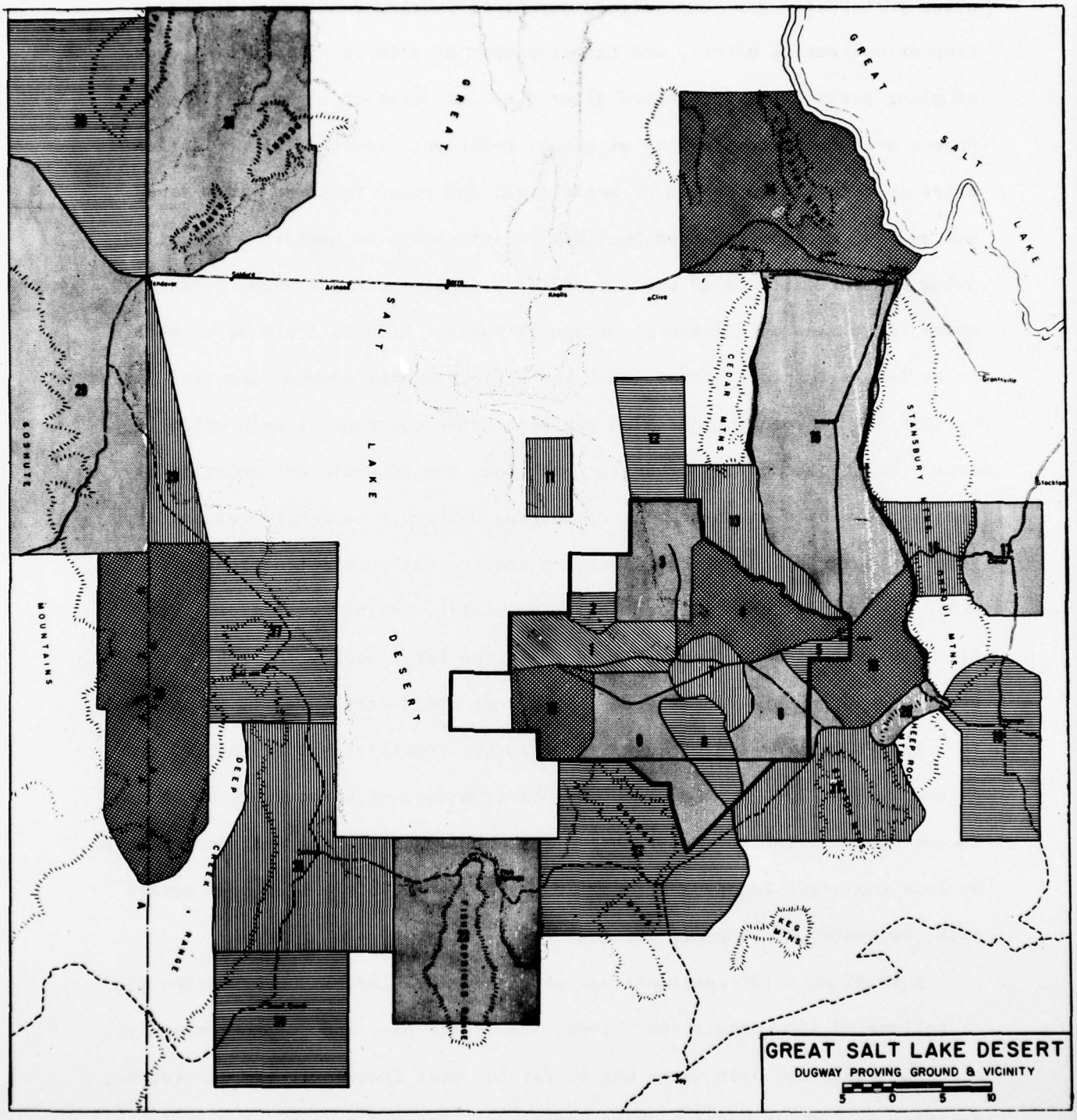
The collecting areas have also been grouped into five geographic arrays which indicate differences in their relative topographic or geographic situation. Table 39 defines the criteria of each array and indicates to which of these zones each collecting area is assigned.

Sampling of rodents and lagomorphs for the Disease Survey was made considerably more systematic during 1963, by the adoption of a collecting schedule as shown in Table 40. This schedule is designed to meet the contractual requirements of the 2,700 rodents and 500 lagomorphs and other non-

avian vertebrates per year. Frequency of collections, seasonal distribution of collecting effort, and target number of animals taken during each sampling period were determined after due consideration of available manpower, seasonal accessibility of areas, geographic location of collection areas in relation to center of activities, and other factors. This schedule and the methods employed should yield specimens in numbers which will allow statistically valid comparisons of disease incidence among different areas to be made on a seasonal or annual basis. Efforts are made to obtain in so far as feasible, coverage of the various biotic communities, the various animal species, and also representative coverage of each collecting area. Modifications of, or deviations from, the schedule are occasionally necessitated by such unforeseen factors as change in manpower availability, very low animal populations, access or transportation difficulties, evidence of a recent or still-continuing epizootic, weather conditions, etc. Since this schedule was not adopted until the first quarter of 1963 was over, some departure from the target numbers and distribution is in evidence for the 1963 collections. In addition to the regularly sampled areas, an effort will be made to secure 50 rodents from each of 4 locations which are in the Complete Control Geographic Array. During 1963 this was accomplished by four one-night trapping efforts in eastern and central Utah near Castle Rock, Duchesne, Huntington, and Loa.

A total of 4,132 specimens was processed for Disease Survey during 1963, as follows: 2,197 rodents, 697 birds, 528 lagomorphs, and 34 other mammals.

As usual, the deer mouse was by far the most frequently trapped rodent, comprising 42.8% of total rodents processed. The Ord kangaroo rat, which accounted for 20% of the total, was the second most frequent; followed by the antelope ground squirrel (6.6%), and the chisel-toothed kangaroo rat (6.5%). These four species have always been the four most frequently trapped and


GREAT SALT LAKE DESERT
DUGWAY PROVING GROUND & VICINITY
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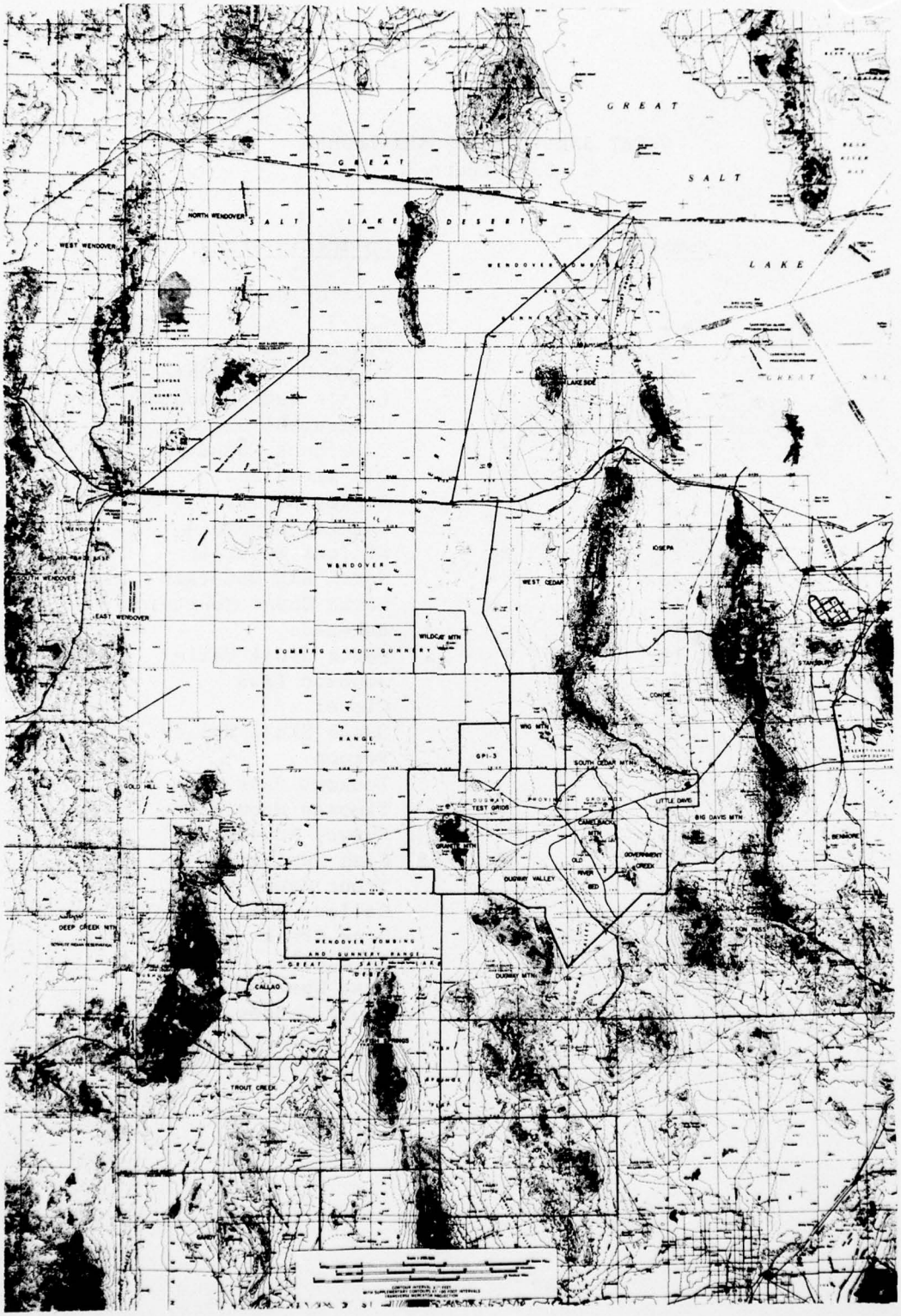
GREAT SALT LAKE
SALT LAKE DESERT
GREAT SALT LAKE
Knolls
Clives
CEDAR MTNS.
STANSBURY
Grantsville
Stockton
ROBERTS
ROSBUTE
MOUNTAINS
DEEP CREEK RANGE
KEG MTNS.
KEEP ROCK MTNS.
OQUIRRH MTNS.

GREAT SALT LAKE DESERT LEGEND
for Figure 1

Number	Collecting Area
1	Test Grids
2	GPI-3
3	Wig Mountain
4	South Cedar Mountains
5	Little Davis Mountain
6	Government Creek
7	Camelback Mountain
8	Old River Bed
9	Dugway Valley
10	Granite Mountain
11	Wildcat Mountain
12	North Wig Mountain
13	North Cedar Mountains
14	Lakeside
15	North Skull Valley
16	Johnson Pass
17	Clover
18	South Skull Valley
19	Vernon
20	Lookout Pass
21	Simpson Mountains
22	Dugway Mountains
23	Fish Springs
24	Trout Creek
25	Callao
26	Deep Creek
27	Gold Hill
28	East Wendover
29	South Wendover
30	West Wendover
31	North Wendover


GREAT
SALT
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NORTH WENDOVER
WEST WENDOVER
WENDOVER
EAST WENDOVER
SOUTH WENDOVER
LAKESIDE
WEST CEDAR
JOSEPH
WILDCAT MTN
BOMBING AND GUNNERY RANGE
CONDIE
STANSBURY
WIG MTN
GPI-3
SOUTH CEDAR MTN
LITTLE DAVE
BIG DAVIS MTN
CAMELBACK MTN
GOVERNMENT CREEK
OLD RIVER BED
DUGWAY VALLEY
GRANITE MTN
DUGWAY TEST GRIDS
DEEP CREEK MTN
GOLD HILL
CALLAO
DUGWAY MTN
TROUT CREEK
SANDY

TABLE 39. Definition of geographic arrays and collecting areas included within each zone.

Geographic Array Zone I - Inner

(0-25 miles from center of collection effort)

Test Grids	Government Creek
GPI-3	Old River Bed
Wig Mountain	Camelback Mountain
South Cedar Mountain	Dugway Valley
Little Davis Mountain	Granite Mountain

Geographic Array Zone II - Intermediate or Outer

(Within 25-50 miles from center of effort)

*North Skull Valley	#Condie
*South Skull Valley	#Iosepa
*North Wig Mountain	#Big Davis Mountain
*Simpson Mountain	#Erickson Pass
*North Cedar Mountains	#West Cedar Mountains
East Wendover	Fish Springs
Joy	Gold Hill
Dugway Mountain	Wildcat Mountain

Geographic Array Zone III - Distance Control

(Within 50-100 miles from center of effort)

Callao	Gandy
North Wendover	Montello
West Wendover	Lucin
South Wendover	Grouse Creek
Trout Creek	Lakeside

Geographic Array Zone IV - Terrain Control

(Protected by mountains and from 25-120 miles from center)

*Vernon	Payson
*Clover	American Fork
*Lookout Pass	Midway
#Stansbury	Saltair
#Benmore	Salt Lake City
Deep Creek Mountains	Fountain Green
Orem	

Geographic Array Zone V - Complete Control

(Protected by mountains and over 120 miles from center)

Duchesne	Loa
Logan	Roosevelt
Castle Rock	Cisco
Ferron	Kemmerer

* Denotes old designation, no longer used after July 1 1964.

# Denotes newly created area and designation.

TABLE 40. Schedule of annual rodent and lagomorph collections for Disease Survey

Area	June-Aug. R	June-Aug. L	Sept.-Nov. R	Sept.-Nov. L	Dec.- Feb. R	Dec.- Feb. L	Mar.- May R	Mar.- May L	Annual Sample per area R	Annual Sample per area L
Camelback Mtn.	24	4	24	4	24	4	24	4	96	16
GPI-3	24	4	24	4	24	4	24	4	96	16
Test Grids	24	4	24	4	24	4	24	4	96	16
Granite Mtn.	24	4	24	4	24	4	24	4	96	16
Dugway Valley	24	4	24	4	24	4	24	4	96	16
Wig Mountain	24	4	24	4	24	4	24	4	96	16

Area	June-August R	June-August L	Sept. - Dec. R	Sept. - Dec. L	January-May R	January-May L	R	L
Government Creek	28	4	28	4	28	4	84	12
Little Davis Mtn.	28	4	28	4	28	4	84	12
Old River Bed	28	4	28	4	28	4	84	12
South Cedar Mtn.	28	4	28	4	28	4	84	12
Condie	28	4	28	4	28	4	84	12
Iosepa	28	4	28	4	28	4	84	12
Big Davis Mtn.	28	4	28	4	28	4	84	12
Erickson Pass	28	4	28	4	28	4	84	12
Dugway Mountain	28	4	28	4	28	4	84	12

Area	June-November R	June-November L	December-May R	December-May L	R	L
North Wendover	40	8	40	8	80	16
South Wendover	40	8	40	8	80	16
East Wendover	40	8	40	8	80	16
West Wendover	40	8	40	8	80	16
Deep Creek Mountains	40	8	40	8	80	16
Gold Hill	40	8	40	8	80	16
Trout Creek	40	8	40	8	80	16
Benmore	40	8	40	8	80	16
Stansbury	40	8	40	8	80	16
Fish Springs	40	8	40	8	80	16
West Cedar Mountains	40	8	40	8	80	16
Wildcat Mountain	40	8	40	8	80	16
Lakeside	40	8	40	8	80	16
Complete Control Area #1	50				50	
Complete Control Area #2	50				50	
Complete Control Area #3	50				50	
Complete Control Area #4	50				50	
Montello		8		8		16
Lucin		8		8		16
Grouse Creek		8		8		16
Gandy		8		8		16
				TOTAL	2652	492

processed for the Disease Survey. However, in the last two years the relative percentage of each has changed considerably from the average of the previous four years, as shown in Table 41, below.

TABLE 41. Percentage of total Disease Survey rodent specimens contributed by each of four most frequently processed species during a six-year period.

Species	1958	1959	1960	1961	1962	1963	Average 1958-61	Average 1962-63
Peromyscus maniculatus	27.9	27.8	27.3	27.0	48.0	42.8	27.5	45.4
Dipodomys microps	23.4	12.5	17.1	17.1	8.1	6.5	17.5	7.3
D. ordii	20.7	13.6	11.9	12.8	14.9	20.0	14.8	17.4
Citellus leucurus	7.3	10.8	13.2	12.1	6.4	6.6	10.8	6.5

Inspection of the table shows that during the last two years, the percentage contribution of P. maniculatus to the total rodent sample increased about one and one-half times, whereas that of D. microps is only about 40%, and of C. leucurus 60% of the previous four-year average. The reasons for this shift are not completely clear since in 1962 trapping methods, biotic community and geographic effort were not radically changed from the preceding years. If the change in composition had been first evident in 1963 it might be readily explainable by a number of changed techniques, including more systematic seasonal coverage of collecting areas, an effort to obtain samples from all parts of the collecting areas rather than old "traditional" sites, more equitable distribution of sampling effort among the various biotic communities, and institution of quotas of animals to be taken from one area at a given time. The latter factor may be quite important since rather than leaving a given trapline set for four consectuive nights, as was previously practiced, the trapline may be removed after only one night if sufficient animals have been obtained to meet the area quota. This is, in fact, quite commonly done during the warmer months of the year when the trapping success is high. Since it has long been shown that D. microps does not usually enter traps in numbers until the third or fourth night of

trapping, whereas P. maniculatus will enter on the first night, the one-night trapping efforts may influence the percentage of these two species caught. Also, since traps are usually set out in the afternoon and taken up early the following morning, the diurnal C. leucurus would have only a relatively short period of time to find and enter the traps.

Table 42 summarizes rodent collections by species from each collecting area, and by zones. Rodents were taken alive in can traps with a line of 40 traps set 33 feet apart constituting one trapline. Whenever possible, traplines within the same collecting areas were set at least a mile apart. A total of 375 such lines were set, for a total of 24,063 trap nights, producing 4,340 rodents.

The species composition of the sample diagnosed for disease entities is an important consideration when comparing total disease incidence among various collecting areas or zones. Differences in susceptibility and antibody persistence, among other factors, among species could easily alter the total incidence in a particular area when examined solely on the basis of total samples diagnosed from an area without regard to species. This would be especially true when certain "signal" species such as D. microps is considered to be for Q fever, constitute a much larger or smaller proportion of the total sample than in a comparison area. Large deviations from the annual average are noted when the rodent collection data are analyzed by geographic array. In Zone I, the deer mouse constitutes a much smaller percentage of the total rodent sample than the annual average, whereas Ord kangaroo rats and ground squirrels are significantly higher. The percentage of the total contributed by each of the four most common species is very close to the overall percentage in Zone II, but in Zone III deer mice are much higher; and in Zone IV both species of kangaroo rats and the ground squirrel form a much smaller percentage than the average.

TABLE 42, Rodents processed for Disease Survey, by areas of collection.

AREAS / ANIMAL SPECIES	Family Sciuridae: Eutamias minimus	E. dorsalis	Citellus leucurus	Family Heteromyidae: Perognathus longimembris	P. parvus	P. formosus	Microdipodops megacephalus	Dipodomys ordii	D. microps	Family Cricetidae: Reithrodontomys megalotis	Peromyscus crinitus	P. maniculatus	P. truei	Onychomys leucogaster	Neotoma lepida	Microtus montanus	Ondatra zibethicus	Family Muridae: Rattus rattus	Mus musculus	AREA TOTAL	ZONE AND GRAND TOTAL
ZONE I																					
Test Grid	25		6				2	30	6	1		22								92	
GPI-3			23	6			6	50	10	1		9								105	
Wig Mountain			9		2	7		39	8	6	2	41		1	6					121	
Camelback	1		17	6				28	8	10	2	34		1	1					108	
Dugway Valley	7		14					45	10	1		11								88	973
Granite Mountain			12	3		19		15	21	5		10			1					86	
South Cedar Mtn.			11			4		36	8	3		18	3	2	7					92	
Little Davis Mtn.			9					58	1	9		25			4					106	
Government Creek			8	2		12		16	5			42								85	
Old River Bed			4	9				51	3	5		18								90	
ZONE II																					
North Skull Valley			9		4	2		10	2	2	2	36			5					72	
South Skull Valley									7	8		59								74	
Simpson Mountain					1	3		11	2			13	1							31	
North Cedar Mtn.					4	1			1	4		18								28	
Condie	1		3		3			29	10	8		13								67	
Iosepa		1			1	1			1	1		19	2							26	
Big Davis Mtn.					10				4	1		27			6					48	
Erickson Pass	3		1		2				3	1		39	5		2					56	906
Dugway Mountain			18			36		8	4	3	5	15			1					90	
West Cedar Mtn.					2	4		7	1	1		23		1	2					41	
Fish Springs			6			35			6	15		21			2	1				86	
Gold Hill			6	5	13	3		4	8		1	43	1		2					86	
North Wig Mtn.			4					31	6			5								46	
East Wendover				3	3	4		10	12	4	2	39	4		6					87	
Wildcat Mountain			1	17		6		28	6	2	1	6		1						68	
ZONE III																					
Lakeside			1					24	4			11								40	
Trout Creek	4		1		7			7	3		1	63	2		2					90	
Callao	4					1		4	4	3		100								116	
South Wendover			5		5	1		10	4			66	2							93	516
West Wendover			7	3	2	1		3	6	4		62			1	1				90	
North Wendover			16	6		3		23	10		1	28								87	
ZONE IV																					
Vernon	6				10					18		14								48	
Clover	23											8								31	
Johnson Pass	2									4		4	1							11	
Lookout Pass		3			18					1		22	1		1					45	
Stansbury	1				8					3		26			1					39	
Benmore	3				18					1		16	2							40	335
Deep Creek	4		3	2	7			6	7	4		54	1							88	
Orem										1										1	
American Fork										2						14	2			21	
Midway										2		7							3	9	
Salt Lake City																		2		2	
ZONE V																					
Duchesne												18	12							30	
Castle Rock	2											68								70	
Ferron											5	51	2							58	187
Loa	1				2							24	1		1					29	
Total	87	4	194	62	122	143	8	583	191	134	22	1248	40	6	50	16	2	2	3		2917
% of Total	3.0	0.14	6.6	2.1	4.2	4.9	0.27	20.0	6.5	4.6	0.7	42.8	1.4	0.2	1.7	0.5	0.07	0.07	0.1		

Table 43 lists the mammals other than rodents collected and processed for the Disease Survey, according to collecting area and zone. Of this group of animals only the black-tailed jack rabbits are collected systematically. They are obtained by shooting with a shotgun, usually from the back of a truck, both during the day and with spotlights at night. Cottontails are collected as opportunity arises while hunting the jack rabbits. The other species are taken by hand, in steel traps, or by shooting, on a chance occurrence basis. Special effort is made during the hunting season to obtain blood specimens from deer by supplying hunters with blood collecting apparatus and instructions. The antelope were immobilized by use of a Cap-Chur gun and the drug succinylcholine chloride.

The large jack rabbit collections from Grouse Creek and Montello are a result of a follow-up effort to collect 50 additional specimens from these areas after tularemia was isolated from a Grouse Creek cottontail, and serological evidence of plague was found in a Montello jack rabbit, both collected earlier in the year.

Both rodent and other mammalian specimens were examined for ectoparasites as they were being processed. Representative samples were collected, sorted into pools with regard to kind of ectoparasite, host species, collecting area, and trapline, and sent to the Disease Survey Laboratory. A total of 10,605 ectoparasites in 450 pools were so processed during 1963. The number of individuals and the number of pools of each kind of ectoparasite were as follows: Fleas, 3,894 individuals and 174 pools; mites, 424 and 17; ticks, 5,226 and 227; and lice, 271 individuals in 32 pools.

Since the last report period, 1,021 lots of ticks have been identified for Disease Survey. These represented 11 species distributed through five genera, as follows: Dermacentor albipictus, D. andersoni, D. parumapertus,

TABLE 43. Mammals other than rodents, processed for Disease Survey, according to area of collection

COLLECTION AREAS	SPECIES: Order Chiroptera — Myotis volans, Hairy-winged bat	Corynorhinchus rafinesquii, Long-eared bat	Tadarina mexicana, Mexican free-tailed bat	Order Lagomorpha — Lepus californicus, Black-tailed jack rabbit	Sylvilagus nuttallii, Nuttall cottontail	Sylvilagus audubonii, Audubon cottontail	Order Carnivora — Vulpes macrotis, Kit fox	Taxidea taxus, Badger	Spilogale gracilis, Great Basin spotted skunk	Lynx rufus, Bobcat	Felis catus, House cat	Order Artiodactyla — Odocoileus hemionus, Mule deer	Antilocapra americana, Prong-horned antelope	AREA TOTALS	ZONE AND GRAND TOTALS
ZONE I															
Test Grid				12										12	
GPI-3				7										7	
Wig Mountain				19										19	
Camelback				18		1					1			20	
Dugway Valley				16										16	185
Granite Mountain				15	1	1								17	
South Cedar Mountain				17		1	1		1					20	
Little Davis Mountain				22		2		1						25	
Government Creek				27		1					1		2	31	
Old River Bed				18										18	
ZONE II															
North Skull Valley				16										16	
South Skull Valley				7										7	
Simpson Mountain				13										13	
North Cedar Mountain					1									1	
Condie				12										12	
Iosepa				4										4	
Big Davis Mountain				12										12	146
Erickson Pass				12	1									13	
Dugway Mountain				20		1								21	
West Cedar Mountain				6			1							7	
Fish Springs			1	10		1								12	
Gold Hill				14		1	1							16	
East Wendover				11										11	
Wildcat Mountain									1					1	
ZONE III															
Trout Creek				16										16	
Callao	1	3		18		2						25		49	
South Wendover				6										6	
West Wendover				23										23	196
North Wendover				9										9	
Montello				53										53	
Lucin				2										2	
Grouse Creek				37		1								38	
ZONE IV															
Vernon				8										8	
Clover				7										7	
Johnson Pass				7		1								8	
Lookout Pass				5										5	62
Stansbury				8										8	
Benmore				8										8	
Deep Creek				13		2								15	
Fountain Green												3		3	
ZONE V															
Cisco												5		5	
Kemmerer					16									16	29
Logan												4		4	
Roosevelt												4		4	
TOTALS	1	3	1	528	19	15	3	1	2	1	1	41	2		618

Haemaphysalis leporis-palustris, Ixodes angustus, I. jellisoni, I. kingi, I. pacificus, Ornithodoros parkeri, O. sparnus, and Otobius lagophilus.

No significant change has been noted in either species composition, host association, or seasonal occurrence of the various species.

Avian collections are summarized in Table 44. Specimens were obtained by shooting with shotguns, or by mist-netting. In addition to the specimens listed here, over 300 birds were collected and processed and turned over to the E and E Branch.

Systematic sampling of the avian populations was not possible in 1963, and all species were collected as available. As a result, seasonal and aeral distribution are not all that might be desired. More California gulls (Larus californicus) were taken than any other species; this collection resulted from a one-day trip to Salt Lake City and Utah Lake specifically to obtain these birds, since their involvement with the psittacosis group of organisms in other areas is well known.

As opposed to the 1963 collections, during 1964 collecting is being confined to a rather limited number of species, primarily raptors, horned larks, meadowlarks, doves, pigeons, blackbirds, house sparrows, and gulls, which because of their known involvement or abundance, would be most likely to play a part in the epizoology of the pathogens under study. We are also striving for greater aeral coverage and a more uniform seasonal distribution of the specimens from resident and migrant flocks, and from known breeding or congregating areas.

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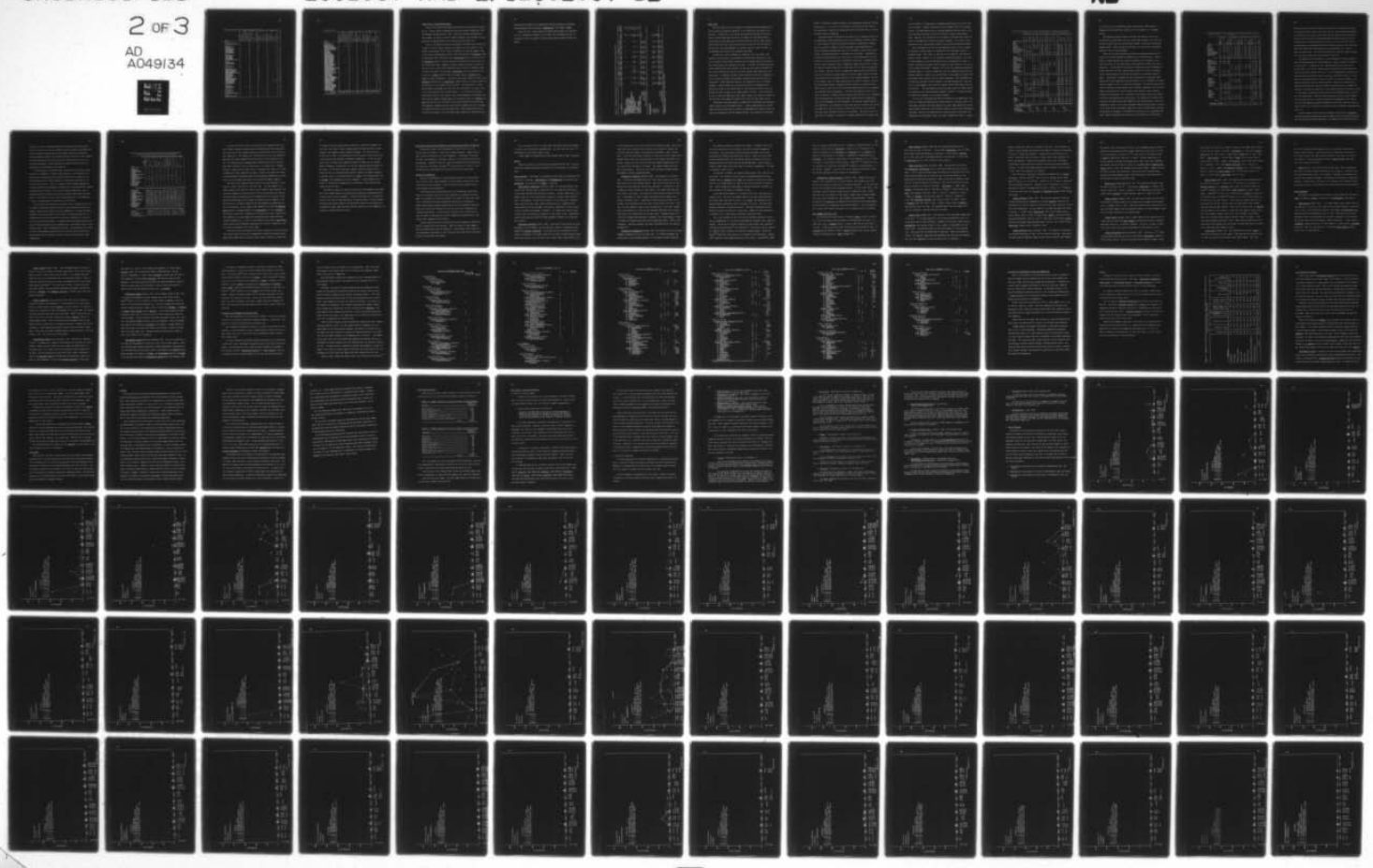


TABLE 44 Birds processed for Disease Survey, according to collection area.

SPECIES	ZONE I						ZONE II				ZONE III					ZONE IV					TOTAL
AREA	Wig Mountain	Dugway Valley	South Cedar Mtn.	Little Davis Mtn.	Government Creek	Old River Bed	N. Skull Valley	S. Skull Valley	Condie	Dugway Mountains	Lakeside	Trout Creek	Callao	West Wendover	Grouse Creek	Lookout Pass	Stansbury	Salt Lake City	Saltair	Payson	Utah Lake	
Pelecaniformes																						
Pelecanus erythrorhynchos											1											1
Anseriformes																						
Anas platyrhynchos											6		1									7
Anas acuta					1						2											3
Spatula clypeata	2					1																3
Anas carolinensis											1											1
Aythya americana																					1	1
Anas cyanoptera											2		4									6
Oxyura jamaicensis						1																1
Falconiformes																						
Buteo jamaicensis				5																		5
Buteo regalis		1								1												1
Circus cyaneus					1									1								2
Falco mexicanus													1									2
Accipiter striatus velox													1									1
Galliformes																						
Alectoris graeca																						0
Phasianus colchicus																	1			11		12
Gruiformes																						
Fulica americana					1						2											3
Charadriiformes																						
Charadrius alexandrinus											4											4
Charadrius vociferus						1					12											13
Numenius americanus						1					1											2
Catoptrophorus semipalmatus											6											6
Totanus flavipes											1											1
Erolia bairdii											3											3
Erolia minutilla																						0
Ereunetes mauri																						0
Limosa fedoa											1											1
Recurvirostra americana											12										4	16
Himantopus mexicanus											7											7
Steganopus tricolor											4											4
Larus californicus																			108		51	159
Larus philadelphia																			1			1
Sterna forsteri																					1	1
Columbiformes																						
Columba livia			1										2									3
Zenaidura macroura				1	17		11		3	1							3					36
Strigiformes																						
Bubo virginianus													1		1							2
Caprimulgiformes																						
Chordeiles minor hesperis					4		2															6
Piciformes																						
Colaptes cafer collaris			1																			

TABLE 44 (continued)

SPECIES	ZONE I						ZONE II				ZONE III					ZONE IV						TOTAL
	Wig Mountain	Dugway Valley	South Cedar Mtn.	Little Davis Mtn.	Government Creek	Old River Bed	N. Skull Valley	S. Skull Valley	Condie	Dugway Mountains	Lakeside	Trout Creek	Callao	West Wendover	Grouse Creek	Lookout Pass	Stansbury	Salt Lake City	Saltair	Payson	Utah Lake	
Passeriformes																						
Tyrannus verticalis					11			1									1					13
Sayornis saya																						0
Eremophila alpestris			4	6	31	32	1	3					3									80
Tachycineta thalassina							4															4
Stelgidopteryx ruficollis																					4	4
Aphelocoma coerulescens			1														1					2
Pica pica												3	1									4
Corvus corax				2		1																3
Parus gambeli			1																			1
Parus inornata				1												1						2
Troglodytes aedon																						0
Salpinctes obsoletus																						0
Mimus polyglottos							1															1
Oreoscoptes montanus					11		1										2					14
Turdus migratorius													1									1
Sialia curricoides			1																			1
Myadestes townsendi													1									1
Bombycilla cedorum																						0
Lanius ludovicianus			1	1	11		1										1					15
Sturnus vulgaris													1					1				2
Dendroica coerulescens																						0
Dendroica nigrescens																						0
Opornis tolmiei							1															1
Sturnella neglecta							2	2					3									7
Xanthocephalus xanthocephalus																					2	2
Agelaius phoeniceus													7									7
Euphagus cyanocephalus							4						5				1					10
Molothrus ater					21		2															23
Hesperiphona vespertina													8									8
Carpodacus mexicana	7			2				3					2									14
Spinus tristis																						0
Spinus psaltria																						0
Chlorura chlorura		2																				2
Pipilo erythrophthalmus													2									2
Passerculus sandwichensis																						0
Pooecetes gramineus										1												1
Chondestes grammacus							5															5
Amphispiza bilineata																						0
Amphispiza belli						3																3
Junco oreganus			3	2									4									9
Spizella passerina																						0
Zonotrichia leucophrys		3			1					1			2									7
Zonotrichia atricapilla																						
Zonotrichia albicollis																						
Melospiza lincolnii													1									
Melospiza melodia													2					12				31
Passer domesticus					17																	
Area Totals	9	6	13	20	127	38	37	12	2	2	65	3	54	1	1	1	10	13	109	11	63	
Zone and Grand Total	213						53				124					207						597

Plague Focus in Indian Farm Canyon:

Study of the Indian Farm Canyon plague focus was continued as time permitted. Regular monthly trapping was done from January through May, 1963, and November through February, 1964. Species of rodents and numbers of each trapped, an index of relative rodent abundance, and incidence of ectoparasites are summarized for each collection period (Table 45).

Even in the absence of positive serological findings and/or tissue isolations it could be safely assumed that plague was still enzootic in the canyon, from analysis of the species composition of rodents trapped, especially relative percentages of each of the three species of Peromyscus. When the percentage that individuals of P. maniculatus bears to the total catch of Peromyscus species is plotted against time during the several years of the Indian Farm Canyon trapping, a strong seasonal variation is observed. This variation is very likely explained by the results of laboratory studies which have shown that whereas P. maniculatus is very resistant to the strains of P. pestis isolated from the canyon, both P. crinitus and P. truei are highly susceptible. During the cold months, upwards of 80% of the Peromyscus captured are P. maniculatus, whereas during the warmer months the contribution of this species falls to 20-50%. The months when the curve swings upward or downward vary with the year, due possibly to annual variations in the onset of cold or warm weather. It is believed that during warm weather when the flea index is low, flea transmission is hampered, and other factors combine to keep plague in a quiescent state, the crinitus and truei survivors as well as those of this species which had not contacted the organism, reproduce and thus increase their numbers and also the number of susceptible hosts in the total population. When conditions favor the flaring up of plague in the cold months these animals are infected and die,

reducing their numbers in the population and thus indirectly increasing the percentage of the resistant P. maniculatus in the sample trapped.

There are still a great number of factors which remain to be explained in the epizoology of plague in this focus, and investigations will be continued in 1964 as progress of work on high priority contact phases will permit.

TABLE 45. Rodents and ectoparasites collected from Indian Farm Canyon plague focus.

Species	1963 Jan	Feb	Mar	Apr	May	1964 Nov	Dec	Jan	Feb	Totals	% of Totals
RODENTS											
Eutamias dorsalis		3		2		2	3	5	5	20	3.9
Perognathus parvus					5					5	1.0
Dipodomys microps		1								1	0.2
Reithrodontomys megalotis	5		1	2						8	1.5
Peromyscus crinitus	7*	8	1		2	3	6		2	29	5.6
P. maniculatus	19	45	63*(2)	79	54*	59*	45	17	5	386	75.0
P. truei	5	3	3	1	7	9	7	5	2	42	8.2
Neotoma lepida	3	1	3			5	2			14	2.7
Microtus longicaudus	3	2	1		1		3			10	1.9
Totals	42	63	75	84	69	78	66	27	14	515	
Trap nights	640	800	800	600	400	320	480	640	480		
Trap nights/animal	15.2	12.7	10.7	7.1	5.8	4.1	7.3	23.7	41.4		
ECTOPARASITES											
Fleas	102	90	69	68	101	180	100	47	15	772	
Mites	36	10	45	33	37	150	109	80	13	513	
Ticks	12	-	12	3	1	-	-	-	-	28	
Lice	33	-	4	6	17	18	-	11	9	98	
Totals	183	100	130	110	156	348	209	138	37	1411	
Fleas/animal	24.3	1.43	0.92	0.81	1.46	2.31	1.52	1.74	1.07		

* *Pasteurella pestis* isolated from rodent tissue.

PE(b) Phase

The basis objective of this phase is the definition and elaboration of those ecological parameters important to the maintenance and spread of infections. In addition to the routine data which have accrued from several years of observations and collections of animals for the Disease Survey, new methods and techniques were initiated during the current report period which provide more data from Disease Survey collections; and also special studies were instituted designed to elucidate upon the natural nidality of the pathogens with which we are presently concerned.

In addition to data regarding the community, trap line number, geographic collecting area, and ectoparasite infestation; information is now also recorded for each rodent processed for the Disease Survey pertaining to age characteristics and reproductive status. A Keysort Card System has been started upon which for each trapline not only are the animals processed for the survey recorded, but also for all other animals taken during the trapping period. In addition, weather factors which may influence trapping success or disease incidence are recorded, along with data on tick and flea infestation, rodent population density, and laboratory results of disease diagnosis. These methods will allow the correlation of pathogens with a variety of factors to be detected and will also provide additional data regarding the basic ecology of the rodent species involved. This analysis is not yet in form for reporting in this annual report, but analysis of both the 1963 and 1964 data should be ready by the end of the next report period.

Essentially, the same methods are employed for recording data regarding rabbits obtained for the Disease Survey. A major change during the current report period has been that all rabbits are processed for tissues as well as blood and ectoparasites by the Ecology Section. This replaces the previous

method of sending the frozen carcasses to the Epizoology Laboratory for processing there. As a result of this change, various data on age criteria and reproductive condition are being collected and recorded that are not obtainable without necropsying.

Population density of potential host species is an important factor in the epizoology of many zoonoses acting not only through a "numbers effect", i.e. more contract between individuals and greater ectoparasite exchange but also indirectly through a density-dependent socio-psychologically-induced feedback mechanism which may alter the member animal's basic physiology, including resistance or susceptibility to disease. Measurements of absolute rodent density on an areal basis in wild populations are very difficult to obtain and would be constantly fluctuating. Determination of relative rodent abundance wherein comparisons among various areas, seasons, or traplines would be made would be sufficient for our needs in epizoological studies. However, there is disagreement among various investigators as to the reliability of measurements or relative rodent density even when such estimates are the primary objective of the trapping program. Because of the dynamic nature of rodent populations, in order to ascertain any correlation between disease incidence and host density, an estimate of such density must be made at the time the rodent samples which will be diagnosed are withdrawn from the population. The collection schedule, both in respect to numbers of animals and area covered, preclude our use of techniques such as trap-mark-and release which would require several trapping days and a grid arrangement for best advantage. The removal method of population estimation is not feasible because about half our traplines are run for one night only, and also because on those lines set for 3 or 4 days the catch per night increases as often as it decreases. The latter is due in some cases to invasion, in others to a changed probability of capture, and

in still others to turning away or trapping characteristics of certain species of rodents. Weather conditions can also strongly affect the trapping success. An added complication to any such population density index is that we are dealing with several species of rodents in several major habitat types. Species, sex, and habitat are all known to influence home range statistics, although such influences are poorly defined. As a result, direct comparison of any index between different areas could be highly misleading.

After consideration of the various problems involved, we have adopted an estimate of rodent density as expressed by the trap-night index as a standard method. This index, as used here as the number of trap nights required to catch a rodent, or its reciprocal success percentage, is, at best, a crude estimate of relative abundance and can be modified by a number of factors including trap density and the number of days traps are set, as well as the factors noted above. However, this is the only population estimation technique known to us that is compatible with our trapping methods and the primary objective of same, that of obtaining a large number of animals from many areas several times a year for disease diagnosis. Some refinements of the index are presently being attempted, including expression on a key species in each community, but these will require further work before they can be evaluated. The relationship between trap-night index and rodent density on two plots in the vegetated dunes community on which all rodents captured are marked and released is also being determined.

In Table 46 is presented the density estimates of the populations from which the rodents processed for the disease survey in 1963 were drawn. The trap nights available have been adjusted for those traps sprung by wind and other weather conditions, and by diurnal animals, as well as for malfunctioning traps. The data are broken down by collecting areas, and season, and consolidated into seasonal, zonal, and annual averages and totals. Overall,

TABLE 46. Relative abundance of rodents on traplines from which Disease Survey specimens were obtained during 1963, as indicated by the trap night index and trapping success, by collecting area, season and zones.

Collection Area	January-March		April-June		July-September		October-December		Area Annual Totals			
	Per cent success	Trap nights per rodent	Per cent success	Trap nights per rodent	Per cent success	Trap nights per rodent	Per cent success	Trap nights per rodent	Trap nights	Rodents captured	Per cent success	Trap nights per rodent
ZONE I												
Test Grid			13.6	7.3	14.7	6.8	6.8	14.8	977	113	11.6	8.6
GPI-3			9.1	11.0	15.8	6.3	7.9	12.7	1183	124	10.5	9.5
Wig Mountain	12.1	8.3	22.0	4.5	32.3	3.1	15.7	6.4	875	157	18.0	5.6
Camelback	5.7	17.6	15.8	6.3	22.2	4.5			1189	138	12.7	7.9
Dugway Valley	1.9	53.4	9.3	10.6	11.1	9.0	11.0	9.1	1423	103	7.2	13.8
Granite Mountain			11.7	8.5	10.0	10.0	10.8	9.3	1119	122	10.9	9.2
South Cedar Mountain	13.5	7.2			29.0	3.4			492	100	20.3	4.9
Little Davis Mountain	12.3	8.1			34.6	2.9			730	138	18.9	5.3
Government Creek	1.8	55.3			12.0	8.3	18.1	5.5	872	69	7.9	12.6
Old River Bed	5.7	17.4			18.9	5.3	19.0	5.3	969	112	11.6	8.6
Average	7.2	14.0	12.8	7.8	18.1	5.5	11.0	9.0	9829	1176	12.0	8.4
ZONE II												
North Skull Valley	9.5	10.2	18.4	5.4					729	102	14.0	7.1
South Skull Valley	12.9	7.8							714	92	12.9	7.8
Simpson Mountain			31.5	3.1					108	34	31.5	3.1
North Cedar Mountain			41.8	2.4					98	41	41.8	2.4
Condie					31.6	3.2	7.1	14.0	723	95	13.1	7.6
Iosepa							8.9	11.3	304	27	8.9	11.3
Big Davis Mountain					12.4	8.0	17.0	5.8	458	64	14.0	7.2
Erickson Pass					18.4	5.4	22.7	4.4	306	63	20.1	4.8
Dugway Mountain			29.9	3.3	25.9	3.8	8.9	11.2	754	125	16.6	6.0
West Cedar Mountain					16.1	6.2			504	81	16.1	6.2
Fish Springs			19.3	5.1	16.4	6.1			755	135	17.9	5.6
Gold Hill			30.4	3.2	31.9	3.1			682	212	31.1	3.2
East Wendover			23.7	4.2	35.5	2.8			726	194	26.7	3.7
Wildcat Mountain					19.2	5.2			370	71	19.2	5.2
North Wig Mountain			47.6	2.1					193	92	47.6	2.1
Average	11.8	8.4	26.9	3.7	21.3	4.7	10.4	9.6	7404	1428	19.3	5.2
ZONE III												
Lakeside					24.1	4.2			266	64	24.1	4.2
Trout Creek			31.7	3.1	42.6	2.3			672	240	35.7	2.8
Callao	30.1	3.3			41.1	2.4			427	145	33.9	2.9
South Wendover			47.3	2.1	25.8	3.9			499	197	39.5	2.5
West Wendover			38.7	2.5	39.3	2.5			537	209	38.9	2.6
North Wendover			34.6	2.9	41.0	2.4			504	185	36.7	2.7
Average	30.1	3.3	37.6	2.7	35.0	2.9			2905	1040	35.8	2.8
ZONE IV												
Vernon	6.4	15.6	33.9	2.9					568	52	10.9	9.2
Clover	6.4	15.6							468	30	6.4	15.6
Johnson Pass	3.9	25.9							311	12	3.9	25.9
Lookout Pass	1.9	51.8	41.9	2.3					404	45	11.1	9.0
Stansbury					20.6	4.8			228	47	20.6	4.8
Benmore					44.6	2.2			177	79	44.6	2.2
Deep Creek			27.1	3.6	48.2	2.1			662	245	37.0	2.7
Average	5.0	20.0	30.9	3.2	38.5	2.6			2818	510	18.3	5.5
ZONE V												
Duchesne							9.3	10.8	389	36	9.3	10.8
Castle Rock							25.5	3.9	364	93	25.5	3.9
Ferron							22.7	4.4	304	69	22.7	4.4
Loa							10.2	9.8	315	32	10.2	9.8
Average							16.8	6.0	1372	230	16.8	6.0

SEASONAL ANNUAL TOTAL - ALL ZONES

Trap nights	6100	6288	7080	4784	24,382
Rodents captured	517	1571	1713	597	4,384
Per cent Success	8.5	25.0	24.2	12.5	18.0
Trap nights/rodent	11.8	4.0	4.1	8.0	5.5

on the basis of over 24,000 trap nights and more than 4,000 captures, trapping efforts produced one rodent in 5.5 trap nights, or 1% trapping success.

The expected seasonal trends in the data are evident, with, on the average twice as much effort per unit catch being required in the late fall, and three times as much in the mid-winter period, as during the spring and summer periods. Zonal averages are variable, but Zone III had the highest success of the five zones trapped.

There are also many difficulties involved in obtaining density estimates for the rabbit populations sampled for the Disease Survey. Again, a method is needed whereby some index of abundance can be obtained at the time the rabbits are collected without undue additional effort and time requirements. We have adopted the method of expressing relative abundance as rabbits seen per mile while hunting from tha back of a truck, following a fairly constant pattern of covering the ground at a relatively constant speed. This method is perhaps even more crude than the trap-night index employed for rodent population density estimates, but is thought to be better than no estimate at all, or subjective evaluation. The rabbits-seen-per-mile term is influenced by many factors such as weather conditions, time of day or night, variations in the visual acuity of the observer, type of habitat, wariness of the rabbits, etc. The value of the term will have to be tested by further investigations and correlations. The estimates of relative abundance for the rabbit populations sampled for the Disease Survey in 1963 are summarized in Table 47 on an area, seasonal, zonal and annual basis. Overall, on the basis of over 650 rabbits tabulated in more than 500 miles of driving and hunting, an average of 1.24 rabbits were seen per mile. Observable seasonal trends in abundance are reflected in the indexes as are variations

TABLE 47. Relative abundance of rabbits by collecting area, zone and season, in populations from which *Disease* Survey specimens were obtained during 1963, as indicated by rabbits seen per mile while hunting from trucks.

AREA	April-June			July-September			October-December			Area Totals		
	Numbers of Rabbits seen	Miles driven	Rabbits seen/mile	Numbers of Rabbits seen	Miles driven	Rabbits seen/mile	Number of Rabbits seen	Miles driven	Rabbits seen/mile	Number of Rabbits seen	Miles driven	Rabbits seen/mile
ZONE I												
Test Grid	9	31.9	0.28	9	4.8	1.8	4	22.5	0.18	22	59.2	0.4
GPI-3	0	10.8	0.0	3	7.5	0.5	6	15.7	0.38	9	34.0	0.26
Wig Mountain	7	4.4	1.6	9	11.1	0.8	5	1.6	3.1	21	17.1	1.2
Camelback	12	0.6	20.0	12	1.5	8.0	7	0.4	17.5	31	2.5	12.4
Dugway Valley	7	5.0	1.4	8	0.8	10.0	8	1.1	7.3	23	6.9	3.3
Granite Mountain	4	32.8	0.12	8	7.8	1.0	4	10.3	0.39	16	50.9	0.3
South Cedar Mountain	7	1.9	3.7	12	2.7	4.4	10	8.4	1.2	29	13.0	2.2
Little Davis Mountain				12	2.1	5.7	7	0.9	7.7	19	3.0	6.3
Government Creek				14	0.6	20.0	5	2.2	2.3	19	2.8	6.8
Old River Bed	9	6.0	1.5	13	4.0	3.2	9	4.7	1.9	31	14.7	2.1
Average	55	93.4	0.6	100	42.9	2.3	65	67.8	0.9	220	204.1	1.1
ZONE II												
North Skull Valley	34	49.5	0.89							34	49.5	0.89
South Skull Valley	18	24.6	0.73							18	24.6	0.73
Simpson Mountain	16	15.7	1.02							16	15.7	1.02
North Cedar Mountain	0	10.2	0.0							0	10.2	0.0
Condie				14	2.4	5.8	8	1.8	4.4	22	4.2	5.2
Iosepa							7	3.0	2.3	7	3.0	2.3
Big Davis Mountain				12	3.2	3.8	8	2.2	3.6	20	5.4	3.7
Erickson Pass				21	4.7	4.5	7	2.2	3.2	28	6.9	4.1
Dugway Mountain				12	6.3	1.9	5	2.4	2.1	17	8.7	1.9
West Cedar Mountains				5	21.9	0.2				5	21.9	0.2
Fish Springs	14	44.3	0.32							14	44.3	0.32
Gold Hill	10	12.0	0.83							10	12.0	0.83
East Wendover				9	5.1	1.8				9	5.1	1.8
Average	92	156.3	0.6	73	43.6	1.7	35	11.6	3.0	200	211.5	0.95
ZONE III												
Trout Creek				10	1.7	5.9				10	1.7	5.9
Callao				10	0.7	14.3				10	0.7	14.3
South Wendover				4	9.4	0.4				4	9.4	0.4
North Wendover				21	32.5	0.6				21	32.5	0.6
West Wendover	16	5.7	2.8							16	5.7	2.8
Lucin	5	5.5	0.91							5	5.5	0.91
Grouse Creek	14	6.0	2.3							14	6.0	2.3
Montello	20	2.5	8.0	39	5.7	6.8				59	8.2	7.2
Average	55	19.7	2.8	84	50.0	1.7				139	69.7	2.0
ZONE IV												
Vernon	23	5.3	4.3							23	5.3	4.3
Clover	13	8.3	1.6							13	8.3	1.6
Johnson Pass	15	2.9	5.2							15	2.9	5.2
Lookout Pass	8	13.2	0.4							8	13.2	0.4
Stansbury				8	2.5	3.2				8	2.5	3.2
Benmore				14	4.6	3.0				14	4.6	3.0
Deep Creek	11	3.3	3.3	8	2.6	3.1				19	5.9	3.2
Average	70	33.0	2.1	30	9.7	3.1				100	42.7	2.3
SEASON TOTAL - ALL ZONES	272	302.4	0.9	287	146.2	1.96	100	79.4	1.26	659	529.0	1.24

between and within areas that correlate fairly well with subjective evaluations made during the actual collecting. Not all rabbit populations sampled are included in this table, since some areas were collected by non-standard methods, and the system of recording mileage and rabbits seen was not instituted until the second quarter of the year. It is of interest that the two isolations of tularemia made from jack rabbits during the year were both made from animals drawn from populations having indexes of 4.7 and 8.0 rabbits seen per mile. Both of these indexes were among the highest recorded on any areas collected during the quarter involved.

The importance of jack rabbits in the epizoology of various pathogens under study has prompted the establishment of a special program of research on this species. A program of live trap-bleed-release was instituted in January 1964, in one of the largest areas of greasewood on Post, where rabbits are relatively abundant all year. A line of approximately 3,500 feet of snow and poultry fencing has been erected as a rabbit-drift fence, in this habitat, with openings every 150 feet in which live-traps are placed. Jack rabbits captured are bled by cardiac puncture, examined for ectoparasites, measured and checked for various biological characteristics, ear tagged and released. The blood is turned over to the Infectious Disease Laboratory where it is processed serologically and isolations are attempted from the clots as well as ectoparasites. From this continuing study we hope to gain information relating not only to population dynamics and movements of the rabbits, but also data regarding antibody persistence in the wild, seasonal changes in rates of infection, differences in infection rates in different age groups and sexes, etc.

Another project dealing with the attempted isolation of R. rickettsii and psittacosis-group organisms from jack rabbits has been instituted jointly with the Infectious Disease Laboratory. The possibility of isolating these

organisms is rather slim when guinea pig inoculation of animal tissues alone is practiced, as per the standard ES phase diagnostic procedures,but is much improved using additional chick embryo inoculation techniques. During necropsy of rabbits for the Disease Survey additional tissue samples are taken and pooled and turned over to the laboratory for use in such isolation procedures. Rodent specimens in excess of Disease Survey requirements are also handled in the same way.

A final project in the PE(b) phase, instituted in the current report period is a by-product of CP phase investigations. The 100-station, 10-acre grid in the Vegetated Dune community which serves a control on the Endrin-treated plot is being trapped for 4 nights per month and will be continued for one year. The live trap-mark-release methods employed are yielding considerable information regarding basic rodent population dynamics including secular trends in sex, age, and species composition, rate of population turnover, species interactions, density, home range, and movements. At the end of one year, the standard methods will be changed and a study of compensation and invasion will be initiated.

The fact that certain species of rodents tend to be found only in certain biotic communities, whereas others are quite ubiquitous and that although a species may be found in several communities it is more frequently trapped in one than in others is well known. Animals processed for the Disease Survey have been tabulated by the biotic community of collection in all previous annual reports. A somewhat different approach has been employed to show species-habitat relationships on a quantitative basis in the present report. Table 48 summarizes this data. The communities are listed in order of decreasing elevation from left to right with the first four being mountain and/or foothills, and the latter five being valley floor communities.

TABLE 48. Rodent-biotic community relationships. Figures in Sections A and B represent frequency ratios of some species to most frequently captured species, or of captures in given biotic community, to community in which species most frequently captured. See text for explanation.

Section A - Relative frequency of captures of different species within each community

SPECIES / BIOTIC COMMUNITIES	Juniper mountain	Mixed brush	Juniper brush	Shadscale-budsage	Greasewood	Shadscale-gray molly-greasewood	Shadscale-gray molly	Vegetated dunes	Marsh	
Eutamias minimus	1	8			1	14	8	3		
E. dorsalis	1									
Citellus leucurus	1	9	10	22	8	14	10	27		
Perognathus longimembris		5		39	1	2		5		
P. parvus	20	9								
P. formosus	3	19				2		0.1		
Microdipodops megacephalus						0.5		2		
Dipodomys ordii	2	7	100	72	23	19	32	100		
D. microps	2	13	4	39	7	13	39	8		
Reithrodontomys megalotis	3	9	4	11	13	2	13	3	100	
Peromyscus crinitus	2	2.5								
P. maniculatus	100	100	42	100	100	100	100	38	93	
P. truei	7	0.5	6							
Onychomys leucogaster		2.5		11				0.2		
Neotoma lepida	5		6			0.5		0.1		
Microtus montanus									37	
M. longicaudus		0.2								
Mus musculus		0.2							7	

TABLE K. Section B. Relative frequency of capture of a species within each of several biotic communities

Eutamias minimus	21	94			8	100	82	37		
E. dorsalis	100									
Citellus leucurus	8	32	38	12	20	34	37	100		
Perognathus longimembris		97		100	14	27		93		
P. parvus	100	29								
P. formosus	26	100				6		1		
Microdipodops megacephalus						17		100		
Dipodomys ordii	2	7	100	10	15	12	28	95		
D. microps	10	37	10	15	12	23	100	23		
Reithrodontomys megalotis	5	10	4	2	10	2	14	3	100	
Peromyscus maniculatus	100	64	28	9	43	42	59	24	53	
P. crinitus	100	92								
P. truei	100	4	59							
Onychomys leucogaster		100		68				16		
Neotoma lepida	100		85			4		2		
Microtus montanus									100	
M. longicaudus		100								
Mus musculus		1							100	

TABLE K. Section C - Distribution of trapping effort and trapping success, by biotic community.

										Total*
Traplines set	73	129	17	11	14	42	6	78	3	373
Trap nights	3730	7804	994	1181	1255	3425	403	4940	335	24,063
% of total trapping effort	15.5	32.4	4.1	4.9	5.2	14.2	1.7	20.5	1.4	100.0
Rodents captured	907	1531	188	53	138	395	80	973	75	4340
Trap nights/rodent	4.1	5.1	5.3	22.3	9.1	8.7	5.0	5.1	4.5	5.5

* Total of all communities.

In Section C of this table, the distribution of trapping effort, the total rodents captured in populations from which Disease Survey specimens were obtained, and the trapping success are tabulated for each of nine biotic communities. The sample size is sufficient in all but the shadscale-gray molly and marsh communities for reliability in the analyses to follow. The distribution of trapping effort reflects the relative areas of each type of habitat in the collection areas in a general way. Trapping success is essentially the same, about 5 trap nights per animal in 6 of the 9 communities, being significantly lower at about 9 trap nights per animal in the greasewood and shadscale-gray molly-greasewood communities, and much lower at 22 trap nights per animal in the shadscale-budsage community.

The species most commonly captured under our present methods of trapping are listed in Section A of the same table. In each community, all rodent captures were sorted by species and the species most frequently captured was assigned an arbitrary value of 100; an index figure for each of the other species occurring within the community was calculated by determining the percentage that the number of animals actually trapped of each species was to the number trapped of the most frequently trapped species. As an illustration, in the Juniper Brush community, for each 100 Dipodomys ordii captured, trapping produced 42 P. maniculatus and 10 C. leucurus on the average, during 1963. Comparisons in Section A can only be made within each community; the index numbers are meaningless when compared between different communities. It will be seen from this table that P. maniculatus was the species most frequently encountered in 6 of the 9 communities, and was second in frequency in the other three.

Section B of the table depicts the relative captures of a given species that would be made in each of the communities in which this species occurs. These index numbers were calculated as were those in Section A, except that

the numbers actually captured were converted to a theoretical number that would have been taken if equal trapping effort had been put forth in each community and trapping success remained unchanged. The values in this section of the table, in contradistinction to Section A, are valid only for a given species when compared in different communities. It will be noted that 6 species reached their maximum frequency of capture in the Juniper Mountain community; included here is the most commonly captured rodent, the deer mouse. Of the other three most commonly collected animals for the Disease Survey, the antelope ground squirrel reaches its highest frequency of capture index in the Vegetated Dunes; D. ordii in the Juniper Brush, and D. microps in the Shadscale-Gray Molly community. Various degrees of fidelity to the different communities by each species is also obvious from inspection of the table.

The number of species of rodents occurring in each community gives some idea of the complex species interactions and ectoparasite exchange possible or likely within a given community. Further verification of all three sections of this table by additional data is required before a reliable quantification of the species density and distribution factor can be worked into a mathematical model expressing the epizootic potential of the communities in relation to various disease entities.

Distribution and host relationships of tick species occurring in study area:

Ectoparasite species vary considerably in their ability to be infected by and to transmit to their hosts various pathogens. Mammal species vary in their susceptibility to these pathogens. A knowledge of the parasite-host relationship is, therefore, important to any program of predictive epidemiology. Ignoffo[37] listed the louse-host associations occurring within our study area, and Parker and Howell[38] treated the fleas. Below is a summarization of our knowledge of the ticks and their host associations.

Sources of information:

Since the establishment of Ecology Research contract with the University of Utah in 1951, many thousands of native mammals and birds have been collected for various purposes. Most of these have been examined more or less diligently for ectoparasites.

Three surveys have contributed most of the information listed below. Early in the overall activities of this organization a general survey was made in an attempt to collect and identify all species of life in the study area. Concurrently with this program and continuing to the present, a disease surveillance of major proportions has been in continuous operation. These two surveys have furnished us with the bulk of our information on tick-host associations. A third survey, carried out for a period of one year, was made to determine the relative abundance of ectoparasites in the various plant communities of the area.

Another important source of material has been the mammal collecting by Harold J. Egoscue and his associates. Other collectors of small mammals have furnished useful bits of information. Deer hunters, both outside of our organization and within it, have collected ticks from the deer they have killed, and from their own persons.

The local agent of the U. S. Army insect and rodent control has brought in several lots of ticks for identification. So, also, have the local U. S. Army hospital and the small mammal clinic.

A small amount of information has been gleaned from the open literature.

Results

Twenty-one species of ticks have been recorded from our area. They are distributed through both major tick families and seven genera, as described below.

Family Ixodidae: This family is represented in our fauna by four genera and 16 species, as follows: Rhipicephalus and Haemaphysalis, one species each; Dermacentor, three species; and Ixodes, 11 species.

Rhipicephalus sanguineus (Latrielle) 1806: Of Old World origin, this tick has been spread by man to practically all the countries of the world lying between 40° North and 40° South latitudes. Its most common host is the domestic dog, but it has been known on occasion to accept a wide variety of hosts, including man. So far we have found it in our area only in housing areas, and at the local small animal veterinary clinic. Numerous males, laying females, larvae and nymphs, were found in residences in March; adults in July; and adults and nymphs in November. All stages were found on dogs in March, July, and October by personnel at the Animal Clinic. Spraying of infested dwellings and treating of dogs apparently brought the infestation under control.

Dermacentor andersoni Stiles, 1908: In our area we have found this tick principally in the foothills and the mountains, usually in association with sagebrush, Artemisia tridentata. In the past we have considered the lower limits of occurrence to be about 6,000 feet, but where suitable habitat occurs below this elevation, the ticks may also be found. This is particularly true

of the foothill area on the east slopes of the mountain ranges. Most of the adults have been collected either from man or his domestic animals, particularly sheep and horses; or from grass and shrubbery, using a flannel drag. A few have been found on rabbits, but none of the other larger native animals such as deer, have been collected in this habitat during the tick season. Adults have been collected from early March through August, with one record from a cottontail in October. The immature stages have been mostly from rodents. Larvae have been found from March through November, and nymphs from March through September.

Dermacentor albipictus (Packard) 1869: This species is a one-host tick. The larvae and nymphs feed on the same large animals as the adult. They remain on the host through ecdysis. Most of our collections of this species have been from deer, during the animal hunt. On October 21, 1961, a female was found attached to a deer hunter in the Deep Creek Mountains near Callao, Juab County. This hunter had been handling a number of slain deer. On November 21, 1963, a female was removed from a domestic ox at Callao, by David R. Terry. Insufficient collecting has been done to establish a clear picture of the life cycle of this tick in this area. However, the only immature ticks we have recovered were 1 larva and 7 nymphs from a deer January 21, 1959, from the Stansbury Mountains, Tooele County. Three males and 8 females were on the same animal. Engorged females collected in the Deep Creek Mountains in November, laid large numbers of eggs in January and February when held at room temperature (63°F - 79°F) in our laboratory. Utah was included in his map of distribution of this species by Cooley.[39]

Dermacentor parumapertus Neumann, 1901: This species is by far the most commonly encountered tick in our study area. It is found throughout the valleys and in the adjoining foothills to elevations of about 6,000 feet.

The adults are primarily parasites of rabbits. Although, in our area they occur most often on jack rabbits, they are by no means uncommon on cottontails. They occasionally feed on various carnivores, and we have one record of a female being attached to a child. Adults are to be found on their preferred host, the jack rabbit, during all months of the year. Engorging females were found from May through September. Adults found attached at other times of the year show no evidence of engorgement. The peak of abundance occurs in July.

In addition to rabbits, the immature forms accept a wide variety of rodent hosts. Our collection records indicate a marked preference for the kangaroo rats, D. microps and D. ordii, but probably all species of rodents that are to be found within the range of the tick are utilized to some extent. Rarely, nymphs have been found on various carnivores; and again, we have recorded one instance of attachment to man.

Larvae have been recorded in all months of the year. Two peaks of abundance occur. The first and highest comes in late March and early April. The second, much lower than the first, is in August and September, and no doubt represents hatching of early-laid eggs of the year. The early peak probably represents overwintering larvae. During the spring peak several hundred larvae may be found on a single host. Nymphs have been recorded in all months, with a single peak of abundance occurring in May.

Due to the abundance of this tick and its resultant potential involvement in epidemiology, it has received considerable attention from a number of workers. Studies on its seasonal abundance on jack rabbits were conducted by Fremling and Gastfriend,[40] and by Rosasco.[41] Data from a similar study of the immature forms on rodents are currently being processed. Allred and Roscoe[42] Studied the life history as it occurred in the laboratory. Jorgensen[43] reported on the oviposition habits of the female. Gastfriend[44] listed

new host records of the immature forms. Woodbury and Parker[45] found it to be naturally infected with P. tularensis; Stoenner et al.,[13] recorded it as naturally infected with P. tularensis, R. rickettsii, and C. burnetii; and Allred et al.,[46] reported it as capable of experimental transmission of P. tularensis. In a study of a plague focus in Utah, Marchette et al.,[47] found no evidence of involvement of this species. Egoscue[48, 49] reported the tick as a parasite of the kit fox; and Howell[50] recorded it as being present in a kit fox den. Ignoffo[51] used it as one of the species with which he evaluated various techniques for the recovery of ectoparasites.

Haemaphysalis leporis-palustris (Packard, 1869: Cooley[7] says of this species, "It is probable that the other rabbits, small mammals, and birds not yet yet recorded as hosts, may be used when available". In our area this tick is not as common as that statement implies. We have found adults, only, on rabbits; and the immature stages mostly on rabbits and birds. Adults have been collected January through August; nymphs, March through December; and larvae, March through June, and September through December. Rabbits, particularly S. nuttallii, are apparently the preferred hosts among mammals; and the foothills are apparently the preferred habitat. In our laboratory, as in others, this species has proven to be a capable vector of tularemia.

Genus Ixodes Latrielle, 1795.

In their excellent work "Ticks of the genus Ixodes in Utah", Allred et al.,[52] list nine species of this genus as occurring within the State. Of these nine, only I. marmotae Cooley and Kohls, 1938, has not been found in our area. In addition we have found three species not recorded by them: I. jellisoni Cooley and Kohls, 1938; I. soricis Gregson, 1942; and one species tentatively identified as I. woodi Bishopp, 1911.

Ixodes angustus Neumann, 1899: We have recorded this species only 3 times from our area, as follows: 1 larva from P. maniculatus, June 15, 1960, Birch Creek, Deep Creek Mountains, Juab County; 1 female from C. leucurus, Oct. 9, 1961, west side of Camelback Mountain, Tooele County; 1 female from P. maniculatus, May 15, 1957, Gold Hill, Tooele County.

Ixodes jellisoni Cooley and Kohls, 1938: This species was described from Perognathus californicus, and all previous records have been from that rodent. Glen M. Kohls was kind enough to confirm this identification by comparing Utah specimens with the type and other California material in the Rocky Mountain Laboratory collections. These are the first records of occurrence of the species outside of California. The host records were also new. We have collected the species as follows: Juab County: 1 nymph from P. formosus, Fish Springs, May 17, 1960 (Wm. H. Johnson); 1 female from P. formosus, Cane Springs, Cedar Mts., April 7, 1953 (H. J. Egoscue); 4 larvae, 1 nymph, P. formosus, same locality, August 27, 1953 (H. J. Egoscue); 3 larvae from Peromyscus crinitus, same locality, April 19, 1960; 1 female, P. formosus, April 20, 1960; 1 larva, 1 nymph, 1 female from P. formosus, same locality, April 22, 1960. One engorged female that was brought alive into the laboratory, laid eggs which did not hatch.

Ixodes kingi Bishopp, 1911: This species is the second most common tick in our area. It is found primarily in the valleys and foothills, but it is not unknown from the lower mountains. Compared with the most common tick, D. parumapertus, this species seldom, if ever, occurs in high numbers on individual hosts. The preferred hosts of the adults appear to be the kangaroo rats. Only rarely have we found them on carnivores. Males are seldom collected. The immature stages show some preference for deer mice and kangaroo rats, but will apparently utilize any rodent that is convenient.

Immature stages were found in all months of the year. Of the rodents examined, the percentages infested have been highest in February and November and lowest in August and September. Females have been collected in all months. Males have been collected in January, April, May, September, October, and December. Except for the months of June, July, and August, collections of adults have been relatively evenly distributed throughout the year. In these three summer months we have collected a total of only 7 adult ticks of this species, all females.

This tick has not received the attention of workers that D. parumapertus has. However, Egoscue[49] found it to be a parasite of kit foxes. Howell[50] found it in a kit fox den. Stoenner et al.,[13] found it uninfected with any pathogen tested for. Marchette et al.,[47] reported it to be uninfected in a study of a plague focus in Utah. Allred et al.,[52] reported it from the study area on D. microps and Perognathus parvus at Fish Springs, Juab County.

Ixodes ochotonae Gregson, 1941: This species, primarily a parasite of small rodents and of lagomorphs of the genus Ochotona from which its name derives, is usually found at elevations above those ordinarily collected by our organization. We have, however, collected specimens four times, as follows: 1 female from P. maniculatus, north end of Simpson Buttes, Tooele County, Sept. 9, 1962; 2 larvae from N. lepida, Indian Farm Canyon, Deep Creek Mountains, Juab Co., July 27, 1962; many larvae from N. cinerea, Granite Creek Canyon, Deep Creek Mountains, Juab Co., and 1 female from P. maniculatus, Dugway Valley, November 8, 1962.

Ixodes pacificus Cooley and Kohls, 1953: The adults of this species are primarily parasites of deer, but will readily attack man. Other workers have found the immature stages in other areas on reptiles and rodents.

We, however, have found them only on the latter, perhaps because we have examined very few reptiles from the normal range of the tick, which is in the hills and mountains. Allred et al.,[52] listed larvae of this species from P. truei at Rush Valley, Tooele Co., in April. We have found larvae on several species of rodents in February, March, April, May, June, September, and October; and one record of a larva on a chipping sparrow, Spizella passerina, June 16, 1954, West Hickman Canyon, Tooele County. Nymphs have been collected in April, May and October. Adults have been collected mostly during the big game hunting season, either from deer or from deer hunters. One record of an adult on man was in May.

Ixodes muris Bishopp and Smith, 1937: This species was reported from our area by Allred et al.;[52] 1 larva from P. maniculatus, 12 August, 1953, Callao, Juab County. Harold J. Egoscue, of our organization, collected six nymphs from M. montanus at Timpie Springs, Tooele Co., August 28, 1958.

Ixodes sculptus Neumann, 1904: One male and one female of this species were found on a spotted skunk in the housing area at Dugway Proving Ground, by H. J. Egoscue, Sept. 2, 1963. This constitutes the only record we have of this tick which appears from the published records to be quite common on many hosts in other localities in the mountain west.

Ixodes soricis Gregson, 1942: A single female of this species was collected Sept. 23, 1962 from Sorex vagrans in South Willow Canyon, Stansbury Mountains, Tooele Co., by Harold J. Egoscue. As far as I am able to ascertain, this is the first record of occurrence of this species in Utah.

Ixodes spinipalpis Hadwin and Nuttall, 1916. Allred et al.,[52] reported this species from our area as one larva from P. maniculatus, August 12, 1953, Callao, Juab Co. We have collected only the immature stages, larvae

from 5 species of birds and 2 species of rodents, and nymphs from 2 species of birds and one rodent, as follows: Juab County: 1 larva from P. maniculatus, April 20, 1961, Callao; 1 nymph from N. lepida, May 24, 1961, Trout Creek. Tooele County: 3 larvae from N. lepida, no date, east side of Granite Peak; 2 larvae, 1 nymph, from Pica pica, June 9, 1954, Skull Valley (J. B. Bushman); 1 larva from Spizella passerina, Oct. 5, 1953 (R. D. Porter); 1 larva, 1 nymph, from Melospiza lincolnii, Oct. 9, 1953, Dugway Valley; 2 larvae from Junco oreganus, Nov. 6, 1953, Clover Creek (R. D. Porter); 1 larva from P. maniculatus, April 16, 1963.

Ixodes texanus Banks, 1908: This species has been recorded from our area by several writers. Allred et al.,[52] records it as a parasite of Spilogale gracilis (= S. putorius) from Callao, Juab County; Darsie and Anastos[54] reported it as occurring on Vulpes macrotis at Dugway, Tooele County. Egoscue[48, 49] lists it as a parasite of V. macrotis in south central Tooele County; and Howell[50] includes it in a list of ticks found in a kit fox den at the same locality. In our area this species might well be called the kit fox tick. Thirty of the 33 collections we have recorded have been from that host species. Twice it was collected from S. putorius and once found in a kit fox den. Larvae have been found in January, May, July, and November; nymphs in May, June, July, November, and December; adults in all months except January, February, March, and August. This tick shows remarkable tenacity of life. Unfed females remained alive for four years and two months after collection, and died then only as a result of an inadvertent over-exposure to heat.

Ixodes woodi Bishopp, 1911: One engorged female from N. lepida is tentatively identified as this species. This specimen was collected June 15, 1962 at the north end of Granite Peak, Tooele County. Held alive

until after oviposition was completed, she is in too poor condition for positive identification. Larvae collected at the same site, and which do not belong to any of the other species included in this study, may also be this species. If these specimens are truly I. woodi Bishopp, they represent a new record for the State.

Ixodes species: As in most studies of this type, there are specimens which are for various reasons unidentifiable as to species. Occasional aberrant specimens probably occur in all species. Specimens with diagnostically critical parts missing or damaged in handling may be impossible to positively identify. Unfamiliarity on the part of the identifier with immature stages, particularly larvae, of some species has caused uncertainty in some instances.

Family Argasidae

This family is represented in our fauna by three genera and six species: Argas, one species; Otobius, two species; and Ornithodoros, three species.

Argas persicus (Oken) 1818: J. P. Newey found a single unfed female of this species in a crevice in the rocks on Little Granite Mountain, Tooele Co., Jan, 14, 1952. Alan Gastfriend recovered 2 fed nymphs from Zonotrichia leucophrys from the Cedar Mountains, Nov. 23, 1953. These three are the only specimens we have collected which are definitely assignable to this species. Seven larvae may also be this species. These records are: 3 larvae from Z. leucophrys, Dugway Valley, Oct. 23, 1953 (Denzer); 3 larvae from Z. leucophrys Cedar Mts., April 21, 1953 (Porter); 1 larva from Junco oreganus, Dugway Valley, Feb. 19, 1954 (Porter).

Otobius megnini (Duges') 1884: This widespread species is usually found in this area on domestic livestock, particularly cattle, but has been known to accept a rather wide variety of hosts. It is probably far more common on local cattle and horses than our few records indicate. This is a single host species, molting on the host and dropping off as a fed, second nymph (Cooley and Kohls)[54]. The adult does not feed. We have collected only second nymphs, from the ground around watering troughs; from cattle, horses, S. audubonii, and Eremophila alpestris, in March, April, May, June, August and October.

Otobius lagophilus Cooley and Kohls, 1940: This tick is primarily a parasite of rabbits, with apparently a strong perference for jack rabbits. We have a single record from P. crinitus, a new host record. It feeds on a single host, molting on the host and dropping off as a fed nymph. The adults have only vestigial mouth parts and do not feed. Bacha[55] studied the life cycle of the local ticks and claimed that unlike O. megnini, there is a single nymphal stage. We have collected larvae and nymphs from all three species of local rabbits and in all months of the year. Females held in the laboratory at room temperatures may go as long as two years before laying eggs. Larvae have not readily accepted domestic rabbits as hosts in our laboratory. This is a tick of the valley floors.

Ornithodoros kelleyi Cooley and Kohls, 1941: This tick is a parasite of bats. In common with a number of other species of the genus, the larvae require a number of days to feed, while the nymphs and adults feed in a very short time. As a result, the latter stages are seldom collected on the host. We have collected this species only five times, as follows: 3 larvae from Eptesicus fuscus, Willow Springs, Stansbury Mts., Tooele Co., Aug. 26, 1954 (Bushman); 6 larvae from Antrozous pallidus, housing area,

DPG, Tooele Co., Aug. 31, 1961 (Johnson and Bushman); 13 larvae from A. pallidus, small cave in Indian Farm Canyon, Deep Creek Mts., Juab Co., July 25, 1962(Smith); 13 larvae from A. pallidus, housing area, DPG, May 16, 1964 (Egoscue); 8 larvae from A. pallidus, same locality, May 18, 1964 (Egoscue). Fed larvae recovered from bats have been successfully reared to adults on guinea pigs in our laboratory. So far we have been unable to feed larvae on any host except the pallid bat, A. pallidus.

Ornithodoros parkeri Cooley, 1936: Due to feeding habits of this tick it is found more commonly in animal burrows than on the animal itself. Howell[50] found it in a kit fox den. We have found it commonly in the burrows of the chisel-toothed kangaroo rat. Larvae and nymphs have been found in small numbers (usually a single tick at a time) on D. microps, C. leucurus, E. minimus, Canis latrans, and V. macrotis. All of these animals and their burrows or nests are to be found on the flat valley floors and closely adjacent piedmont. Larvae have been collected from animals in May, June, August, and Sepember; nymphs in March, June, and September. Adults and nymphs were found in the burrows of D. microps in all months. Perhaps because of their small size, few larvae were found in the burrows. Ticks of this species are notably long lived. Specimens which were collected in 1958 are still alive (1964) in our laboratory.

Ornithodoros sparnus Kohls and Clifford, 1963: It will be noted that a new tick name has appeared in this list, over lists of other reports. Kohls and Clifford, Rocky Mountain Laboratory, finally published a description of the tick which has been variously listed in our reports as O. hermsi Wheeler, Herms and Meyer, an atypical O. hermsi, and Ornithodoros species near hermsi. It is now officially known as Ornithodoros sparnus Kohls and Clifford, 1963.

This species is apparently primarily a parasite of wood rats, being found principally in their nests and on animals which probably visit these nests. Beck and Allred[56] made a seasonal study in part of our area, of this tick as found in wood rat nests (as O. hermsi). Davis and Mavros[57] reported in part on its life history (as an atypical O. hermsi). Marchette et al.,[47] reported it (as O. hermsi) as occurring on P. maniculatus, P. crinitus, and N. lepida. Kohls and Clifford[58] described the species in part from our material. Beck[59] reported it (as O. hermsi) from Joy and Jericho, Juab County. Johnson (in press) reported on the ecology, known hosts, and life history of the species in our area. Larvae have been collected in March, April, May, June, September, and October; nynphs and adults throughout the year. Collections have been made from the valley edges to about 7,000 feet elevation.

Ecological relationships of ticks and hosts

More than 2,000 birds of 247 kinds were examined. Ticks were recovered from only 31 individuals distributed through 26 species. Surprisingly, five genera of ticks were represented by one species each.

Many thousands of mammals (estimated at not less than 40,000) have been examined. Of the 69 species of native mammals known to inhabit the area, we have found ticks on 36. Five of the seven introduced or domestic species have yielded ticks.

All told, 68 kinds of vertebrate animals were found to be infested with 21 species of ticks, distributed through both major tick families and seven genera. No representatives of a number of native animals were examined. For instance, neither a Bassariscus astutus nor a Felis concolor, both species known to occur in limited numbers in our area, was ever seen either

alive or freshly dead by any member of our organization. Very few of some other species, particularly some of the carnivores, were examined, simply because they were not trapped for.

Very few domestic animals were examined for ticks, although numbers of three species, sheep, cattle, and horses are fairly numerous during certain seasons.

Therefore, the overall tick-host associations are incompletely known, except for those species, particularly rabbits and rodents, which are commonly collected in numbers by our disease surveillance effort. The large numbers of animals involved, plus the fairly good examination they receive, gives a good indication of kinds and times of infestation. In contrast to this source of information is our sporadic examination of domestic animals. Only 25 sheep were examined and all were infested with D. andersoni. But these sheep had been feeding for some days in prime tick habitat during the height of the tick season. The implication that all sheep are infested with this tick is undoubtedly far from the truth.

Under "Status" heading, in the following host association lists, figures from two sources are used. For host species which are sampled in fair to high numbers by our disease survey program, the figures on the same line as the name of the host represent the number of infested specimens as the numerator over the number examined as the denominator of a fraction. The numbers on the same line as the tick species name represent the decimal fraction or percentage of animals examined that were infested with that particular species of tick. In instances where insufficient animals were examined, or where the number is not known, the whole figure on the same line as the name of the tick represents the total times that species has been recorded from that host.

Names of hosts, except the spotted skunk, are from Miller and Kellogg.[60]

HOST-TICK OCCURRENCE CHECK LIST

	Life stage L	N	A	Status
Class REPTILIA				
Order Squamata				
Family Colubridae				
Coluber taeniatus				
I. kingi	X			1
Class AVES				
Order Strigiformes				
Family Strigidae				
Bubo virginianus (Gmelin)				
Dermacentor species	X			1
Order Piciformes				
Family Picidae				
Colaptes cafer (Gmelin)				
H. leporis-palustris	X			1
Order Passeriformes				
Family Tyrannidae				
Myarchus cinerescens (Lawrence)				
H. leporis-palustris	X			1
Empidonax wrightii Baird				
H. leporis-palustris	X			1
Family Alaricidae				
Eremophila alpestris (Linnaeus)				
O. lagophilus		X		1
Family Corvidae				
Pica pica (Linnaeus)				
I. spinipalpis	X			1
Corvus corax Linnaeus				
Ornithodoros species	X			1
Family Troglodytidae				
Troglodytes aedon Vieillot				
H. leporis-palustris	X			1
Family Muridae				
Dumatella carolinensis (Linnaeus)				
H. leporis-palustris	X			1
Oreoscoptes montanus (Linnaeus)				
H. leporis-palustris	X			1
Family Turdidae				
Myadestes townsendi (Audubon)				
H. leporis-palustris	X			1
Family Parulidae				
Dendroica auduboni (Townsend)				
H. leporis-palustris	X			1

HOST-TICK OCCURRENCE (cont'd)

	L	N	A	Status
Family Parulidae (cont'd)				
Dendroica nigrescens (Townsend)				
H. leporis-palustris	X			1
Icteria virens (Linnaeus)				
H. leporis-palustris	X			1
Family Thraupidae				
Piranga ludoviciana (Wilson)				
H. leporis-palustris	X			1
Family Fringilidae				
Pipilo erythrophthalmus (Linnaeus)				
H. leporis-palustris	X			3
I. spinipalpis	X			1
Passerculus sandwichensis (Gmelin)				
H. leporis-palustris	X			1
Pooecetes gramineus (Gmelin)				
Dermacentor species	X			1
Amphispiza belli (Cassin)				
H. leporis-palustris	X			1
Junco oreganus (Townsend)				
Dermacentor species	X			1
H. leporis-palustris	X			1
I. spinipalpis	X			1
Junco caniceps (Woodhouse)				
H. leporis-palustris	X			2
I. pacificus	X			1
I. spinipalpis	X			1
Spizella breweri Cassin				
H. leporis-palustris	X			2
Zonotrichia leucophrys (Forster)				
H. leporis-palustris	X			1
A. persicus		X		1
Argas species	X			2
Melospiza lincolnii (Audubon)				
I. spinipalpis	X			1
Ixodes species	X			1
Melospiza melodia (Wilson)				
H. leporis-palustris	X			1
Class MAMMALIA				
Order Insectivora				
Family Soricidae				
Sorex vagrans Baird				
I. soricis			X	1
Order Chiroptera				
Family Vespertilionidae				
Eptesicus fuscus (Palistode Beauvois)				
O. kelleyi	X			1
Antrozous pallidus (LeConte)				
O. kelleyi	X			4

HOST-TICK OCCURRENCE (cont'd)

	L	N	A	Status
Order Primates				
Family Hominidae				
Homo sapiens Linnaeus				
D. albipictus			X	1
D. andersoni			X	many
D. parumapertus		X	X	2
I. pacificus			X	7
Order Lagomorpha				
Family Leporidae				
Lepus californicus Gray				910/1552
D. andersoni	X	X	X	.002%
D. parumapertus	X	X	X	.507%
H. leporis-palustris	X	X	X	.014%
O. lagophilus	X	X		.052%
Sylvilagus nuttallii (Bachman)				4/24
D. andersoni		X		.041%
D. parumapertus	X	X	X	.083%
H. leporis-palustris	X	X	X	.166%
I. kingi	X			1
O. lagophilus		X		1
Sylvilagus audubonii (Baird)				
D. andersoni			X	1
D. parumapertus	X	X	X	.081%
H. leporis-palustris	X	X	X	.098
I. kingi	X			1
O. lagophilus	X	X		4
Order Rodentia				
Family Sciuridae				
Citellus leucurus (Merriam)				55/869
D. parumapertus	X	X		.052%
I. kingi	X	X	X	.011%
I. angustus			X	1
O. parkeri				2
Citellus townsendii (Bachman)				
O. lagophilus	X			1
Citellus variegatus (Erxleben)				
I. kingi	X			1
Eutamias minimus (Bachman)				2/63
D. parumapertus	X	X		.012%
H. leporis-palustris	X			1
O. parkeri	X			1
Eutamias dorsalis (Baird)				5/66
D. andersoni	X	X		.045%
D. parumapertus	X	X		.020%
I. pacificus	X	X		.060%

HOST-TICK OCCURRENCE (cont'd)

	L	N	A	Status
Family Heteromyidae				
Perognathus longimembris (Coues)				81/315
D. parumapertus	X	X		.257%
I. kingi	X	X		.009%
Perognathus parvus (Peale)				93/342
D. andersoni	X	X		.152%
D. parumapertus	X	X		.020%
I. kingi	X	X	X	.082%
I. pacificus	X			1
Perognathus formosus Merriam				19/387
D. parumapertus		X		.008%
D. jellisoni	X	X	X	.008%
I. kingi	X	X		.026%
I. pacificus	X		X	.005%
O. sparnus	X			.003%
Dipodomys ordii Woodhouse				274/1115
D. andersoni	X			1
D. parumapertus	X	X		.174%
I. kingi	X	X	X	.129%
Dipodomys microps (Merriam)				312/1099
D. parumapertus				.211%
I. kingi				.133%
O. parkeri				.004%
Microdipodops megacephalus Merriam				2/24
D. parumapertus	X	X		.083%
I. kingi		X		2
Family Cricetidae				
Reithrodontomys megalotis (Baird)				5/335
D. andersoni	X			1
D. parumapertus	X	X		.006%
I. kingi	X	X		.009%
Ixodes species	X			1
Peromyscus crinitus (Merriam)				4/181
D. parumapertus	X			.006%
I. jellisoni	X			1
I. kingi	X	X		.011%
I. pacificus	X			.011%
O. lagophilus		X		1
O. sparnus	X			1
Peromyscus maniculatus (Wagner)				303/2803
D. andersoni	X	X		.004%
D. parumapertus	X	X		.018%
I. angustus	X	X	X	1
I. kingi	X	X		.088%
I. muris *	X			1
I. ochotonae			X	1
I. pacificus	X	X		.005%
I. spinipalpis	X			1
O. sparnus	X			1
Otobius species	X			1

* Reported from literature but not recorded by us.

HOST-TICK OCCURRENCE (cont'd)

	L	N	A	Status
Family Cricetidae				
Peromyscus truei (Shufeldt)				33/360
D. andersoni	X	X		.050%
D. parumapertus	X	X		.006%
I. angustus	X			1
I. kingi	X	X		.014
I. pacificus	X			.044
O. sparnus	X			1
Onychomys leucogaster (Wied-neuwied)				12/25
D. parumapertus	X	X		.120
I. kingi	X	X		.440
O. sparnus	X			.040
Neotoma lepida Thomas				11/184
D. andersoni	X			.005
D. parumapertus	X	X		.032
I. kingi	X	X		.021
I. ochotonae	X			1
I. pacificus	X	X		.005
I. spinipalpis		X		1
I. woodi ?			X	1
O. sparnus	X			.005
Neotoma cinerea (Ord)				
D. andersoni	X			1
I. kingi	X	X		3
I. ochotonae	X	X		1
Microtus montanus (Peale)				
I. muris		X		1
Microtus longicaudus (Merriam)				
D. andersoni	X	X		2
Family Zapodidae				
Zapus princeps Allen				
D. andersoni	X			1
Family Erethizontidae				
Erethizon dorsatum (Linnaeus)				
D. andersoni		X		2
Order Carnivora				
Family Canidae				
Canis familiaris Linnaeus				
R. sanguineus	X	X	X	3
I. kingi			X	2
Canis latrans Say				
D. parumapertus		X	X	3
I. kingi			X	6
Vulpes macrotis Merriam				29/58
D. parumapertus		X	X	8
I. kingi	X	X	X	22
I. texanus	X	X	X	29
O. parkeri		X		1

HOST-TICK OCCURRENCE (cont'd)

	L	N	A	Status
Family Mustelidae				
Mustela frenata Lichtenstein				
I. kingi		X		1
I. texanus	X	X		1
Taxidea taxus (Schreber)				
I. kingi	X	X	X	5
Spilogale putorius (Linnaeus)				
I. kingi	X	X		5
I. sculptus			X	1
I. texanus		X	X	2
Family Felidae				
Felis catus Linnaeus				
D. parumapertus			X	1
Lynx rufus (Schreber)				
D. parumapertus		X		2
I. kingi	X			1
Order Perissodactyla				
Family Equidae				
Equus caballus Linnaeus				
D. albipictus			X	1
D. andersoni			X	11
O. megnini		X		1
Order Artiodactyla				
Family Cervidae				
Odocoileus hemionus (Rafinesque)				
D. albipictus	X	X	X	10
I. pacificus				4
Family Bovidae				
Bos taurus Linnaeus				
D. albipictus		X		1
O. megnini		X		7
Ovis aries Linnaeus				25/25
D. andersoni				1.000

Ecological relationships of ticks and communities.

Early in the history of the University contract effort at Dugway, E. Dean Vest mapped the plant ground cover of the area and determined that there were eight distinct plant communities recognizable. Subsequent intensive rodent trapping established the fact that each plant community had its characteristic animal population. To determine whether or not any inter-community differences existed in the ectoparasite populations, a trapping program was set up whereby rodents of each community could be captured and searched for ectoparasites.

Typical sites were selected by Mr. Vest in each community and a line of 100 live traps set in each. Each line represented a one-acre plot. Beginning in April 1958, and ending in March 1959, these traps were baited and opened for four nights each month, for a total of 4,800 trap nights in each community.

Traps used were can-traps, made of quart oil cans and Museum Special mouse traps, the same traps as are used in our Disease Survey program.

Trapped animals were bagged individually in polyethylene bags and kept on dry ice until processed. Processing consisted of vigorously brushing each animal over a white porcelain pan, then placing the animal in a quart mason jar about half full of detergent, and shaking vigorously, 100 times. The carcass was then removed from the jar and discarded, and the detergent solution strained through a 200-mesh bronze screen. The parasites were then retrieved from the screen and pan, counted, recorded as to general category, and preserved in glass vials in 70% ethyl alcohol for specific determination.

Results.

Although the study area has at least 21 kinds of ticks, only three were recovered during this survey. They were: Dermacentor parumapertus, Ixodes kingi, and Ornithodoros parkeri. Ornithodoros parkeri was recovered so few times that in calculating the results it was disregarded.

The number of animals captured was 1759, of 13 kinds. Numbers from various communities ranged from a low of 21 in the shadscale-gray molly to a high of 467 in the juniper brush.

Only one species, Peromyscus maniculatus, was found in all eight communities. Two others, Dipodomys microps and D. ordii, were trapped in all communities except the shadscale-gray molly, in opposition to the results of the general Disease Survey. Citellus leucurus was found in all but this community and the shadscale-gray molly-greasewood. These four species accounted for 91.4% of the total catch.

Marked inter-community differences were found in all elements of the study which were reviewed (Table 49). Communities which supported large populations of rodents also supported large populations of ticks, in absolute numbers of ticks per acre, in ticks per animal, or tick indices, and in the percentages of animals infested.

TABLE 49. Comparison of infestation activities of ticks in eight different biotic communities observed during a 12-month study, 1958-1959.

Community	Total animals	Number infested	Per cent infested	Per cent infested with *D. parumapertus*	Per cent infested with *Ixodes kingi*	Per cent infested with both species	Total ticks	Ticks per infested host	Tick index	Ticks per acre per month
Greasewood	131	67	.5114	.7678	.1428	.0892	1394	20.8	10.6	116.1
Pickleweed	111	22	.1981	.3125	.6250	.0625	54	2.5	0.5	4.5
Shadscale-budsage	208	142	.6826	.2148	.6198	.1652	2828	19.9	13.6	235.6
Juniper brush	467	296	.6338	.3944	.3386	.2669	7842	26.5	16.8	653.5
Mixed brush	456	272	.5964	.4132	.1239	.4628	4328	15.9	9.5	360.6
Vegetated dunes	313	160	.5111	.2061	.5114	.2824	2758	17.2	8.8	229.8
Shadscale-gray molly-greasewood	52	10	.1923	.0769	.9230	.0000	66	4.7	1.3	5.5
Shadscale-gray molly	21	8	.3809	.1111	.8888	.0000	31	3.9	1.5	2.6
Totals	1759	977	.5554	.3121	.5216	.1661	19301	19.8	11.0	210.0

Tick Colonization Program

Ticks of the species Ornithodoros capensis which had survived from the 1962 field expedition laid viable eggs in fair numbers. Larvae were placed on chickens, pigeons and a common noddy tern, and attached in fair numbers to all three species of birds. Those on the chickens and pigeons detached after several days and none were recovered. Six days after receiving the larval ticks, the tern died. The larvae were insufficiently engorged to survive and all were lost. By June, 1964, all of the ticks of this species which were collected at Eniwetok in April and May, 1962, had died except one male.

Additional ticks of this species were received from Ecology and Epidemiology Branch, DPG, but arrived after the egg laying season of the tick, and although most of them fed readily enough on chickens and terns, none laid eggs. Most of them are still alive, and will probably lay eggs next January or February.

Ticks of the species O. denmarki, also a pelagic bird parasite, were received from E and E Branch and fed on chickens and terns, and laid eggs in fair numbers. An estimated 500-600 larvae were placed on young chicks and on nearly grown chickens. They attached readily, but as in the case of O. capensis, began detaching within a few days. Only 17 engorged larvae were recovered. Of these, six died before completing the first molt, and although the adults fed again, there were no eggs produced. Apparently this species is similar to O. capensis in that a single clutch of eggs is laid each year, but the laying season seems to be about one month later than that of O. capensis.

Ornithodoros kelleyi, a parasite of bats, have heretofore been successfully reared in our laboratory only from fed larvae recovered from wild bats. This season a living pallid bat, Antrozous pallidus, became available for use just as the first of two clutches of eggs hatched to larvae. Of about 30 active

larvae placed on the bat, 8 were recovered in a state of sufficient engorgement to molt twice to second stage nymphs. The first stage nymph of this tick species does not feed. Thirty of the second lot of larvae were placed on the bat, and 10 have been recovered. More are still engorging. Apparently three weeks' time is required for most of the ticks to engorge.

It seems that our ability to produce and maintain a colony of O. kelleyi is dependent on our ability to secure and maintain live bats in captivity. Larvae failed to engorge on 6 species of mice. Unfed larvae have a life expectancy of nor more than about 15 days at room temperature. The total life expectancy is several years.

We have had difficulty in attempting to get larvae from O. parkeri. Adults have fed only sporadically and only rarely produced eggs. This spring, however, all females and many males in our laboratory colony fed on guinea pigs. Most females laid some eggs, and some laid more than 100 each, which is fairly high for this species, in our experience. However most of the eggs failed to hatch and only about 100 larvae will be available for experimental use.

One additional species of common tick, D. andersoni, has been added to our active colony for use in the laboratory.

Flea Colony

After the move from GPI-1 to Bldg. 4218, our flea colonies were progressing nicely until it became necessary to move them into the glassed-in portion of the building while the rest was being painted. The high temperatures experienced in that part of the building destroyed most of the colonies. They are again in process of being rebuilt, but it will be some time before fleas will be available in sufficient numbers for experimental work. The high temperatures in the "green house" had not been anticipated, or other areas would have been employed as temporary housing.

CP Phase

Previous work done by Ecology and Epizoology Research in Control Procedures investigations was reported in the annual reports for 1956 through 1960. Major effort was centered on the application of the chlorinated hydrocarbon insecticide, Dieldrin, at rates of 0.75 to 1.5 lbs/acre by ground and aerial spray application on 10 and 20-acre plots in the Vegetated Dunes and Juniper Brush biotic communities, respectively. Rapid reduction of the ectoparasite population occurred and significant control effects continued for at least three and one-half years following application.

Since ectoparasites have been proven to play a key role in the epizoology and epidemiology of tularemia, plague, and Rocky Mountain spotted fever, and are at least involved in the transmission of Q fever, employing Dieldrin as per methods already tested by this organization would probably be quite effective in halting an epizootic or preventing establishment of an endemic focus. However, in the case of anthrax or Q fever, transmission by aerosol may occur, and large-scale tularemia epizootics have occurred among rodents where the principal mode of transmission was by cannibalism. In such instances, control of ectoparasites alone would probably be ineffective. Also, no instance is known in the literature wherein enzootic plague has been quelled by use of flea control methods; rodent control has been the only means extensively used. On the other hand, rodent control alone, without concurrent ectoparasite control, would not be indicated, especially in the case of outbreaks of plague, tularemia or spotted fever. Indeed, it could conceivably make the situation even worse by forcing ectoparasites to change from feral hosts to domestic animals, livestock, or humans. Therefore, in most cases involving outbreakd of the diseases with which we are presently concerned, it would seem highly desirable to attack both hosts and ectoparasites with a single control measure.

Ideally, in the realm of chemical control, we are seeking a compound which could be broadcast as a spray or a dust by airplane or ground equipment; which is both an oral and a contact poison; is effective against a wide variety of animal species, both mammalian and arthropod; and which has considerable residual effect. The last-named characteristic is desirable in order to kill the rodents that will invade the depopulated area shortly after elimination of the residents, and while the area might still contain disease nidi in the form of spores, infective carcasses, or infected ectoparasites, deep in uninhabited burrows which had not yet been exposed to the insecticide.

The literature and personal communications with a number of experts in this field indicate that the chlorinated hydrocarbon Endrin is at present the chemical most nearly approaching this ideal. Although chemically closely related to Dieldrin, it is approximately 5-10 times as poisonous to experimental animals and is considered the most toxic of all chlorinated hydrocarbons now commonly in use. Ground spraying with Endrin at a rate of 1.2 to 2.4 lbs. actual Endrin per acre is an established practice to control orchard infestations of meadow mice (Microtus spp.) and pine mice (Pitymys pinetorum) in Washington, Oregon, and Virginia.

The primary field test involves a 10-acre plot in the Vegetated Dunes community on the west side of Camelback Junior Mountain, which was sprayed on 9 April 1964 with Endrin in the emulsible concentrate formulation. The pesticide was applied with a 30-foot horizontal boom sprayer at a rate of 5.0 lbs. actual Endrin in 100 gallons of water per acre. A control plot as ecologically equivalent as could be ascertained, was established 0.6 miles from the spray plot. A grid was established on each plot, consisting of 100 stations at 60-foot intervals in a 10 x 10 pattern, at which live

traps were set. Rodent populations were estimated just prior to treatment and at regular intervals afterward by a trap-mark-release method. Ectoparasite infestations were determined by bringing the animals to the laboratory and hand-picking ticks and removing other ectoparasites with a vacuum apparatus before taking the animal back to the field and releasing it at its point of capture.

Soil and vegetation samples were taken prior to treatment and at various intervals afterward, and shipped to a commercial laboratory for Endrin residue analysis.

The acute oral and dermal LD_{50s} were determined for the four most common rodent species on the plots to ascertain species and sexual differences in susceptibility which may explain differences noted in the species composition following application of the pesticide.

At this writing preliminary results indicate that both rodents and their ectoparasites may be controlled by the means employed in spite of very adverse weather conditions following application, and a large amount of ingress of rodents to the sprayed area from surrounding areas where trapping success may be as high as 1.1 trap nights per animal. Full details and analysis of the results of this experiment will be presented in a special report and a summary of the results in next year's annual report.

Faunal Rearing Studies.

Laboratory-reared small mammals supplies to other sections are listed according to Section in Table 50 and according to Species in Table 51.

TABLE 50. Mammals supplied to various sections. Listed by Section

Section	Number of animals
Bacteriology	2,647
Epizoology Laboratory	1,313
Disease Survey	195
Vector transmission	29
Faunal Laboratory (carnivore food)	226
Project Officer	100
University of Utah (various departments)	171
Total	4,681

TABLE 51. Mammals supplied to various sections. Listed by Species

Species	Number of animals
Deer mice	2,793
Pinyon mice	388
Canyon mice	68
Brush mice	42
Western harvest mice	86
Western grasshopper mice	408
Desert wood rat	265
Bushy-tailed wood rat	4
Montane vole	555
Black-tailed jack rabbit	1
Polynesian rat	85
Total	4,681

About 475 mammals were used as breeding stock replacements, and there were approximately 1,200 animals on hand at the end of the report period, giving a grand total of 6,500 animals produced during the year.

Data analyses of the findings from a study of flea-small mammal seasonal relationships in a vegetated dune community are about 75% completed.

Nine kit foxes were tagged. No foxes tagged within the boundaries of the Post were trapped outside the Post.

PE(c) Phase - Predictive Analysis

A. Predictive Analysis Model:

1. Study of the incidence rate of the diseases of interest indicates that it varies with the function of a great many parameters. Some of these are rather obvious; others are, at this point, complete imponderables.

2. Thus a general model may be derived as:

Incidence rate $\propto f$ population density x f Eco-geography x f Population distribution x f Community relations x f Climatic conditions x f Availability of food x f Immunity x f Susceptibility x f Transmissibility x f Lethality + f other variables.

3. To equate this model required the determination of "Constants" for each of these functions. However, since such items as biotic communities, geography, and a host of other parameters would affect the value of the "constant" in each case, such "constants" could be determined only as integral limits or as an average. The solution of such equations by hand is far beyond the capabilities of the present "state of the art" and of the contractor's staff.

4. Therefore, an attempt is being made to correlate the data presently available covering the past 13 years from the ecological collection effort with epizoological diagnosis obtained on these samples. These data have been codified for "punching" on IBM cards and possible later on tape for easy storage.

5. DECK ONE contains all available collection data on the samples and codification for this deck is complete from 1954 to the present date. DECK TWO (C. burnetii), DECK THREE (B. anthracis), DECK FOUR (P. tularensis), DECK FIVE (P. pestis), DECK SIX (R. rickettsii), DECK SEVEN (Psittacosis, and DECK EIGHT (Brucellosis) have been codified from 1 July 1957 to date, for epizoological diagnosis.

6. This codified data on University of Utah computer data sheets has been turned over to the appropriate Computer Center for "card punching" and storage. It is anticipated that these IBM cards will have been prepared by 15 July, 1964, at which time it is anticipated that a series of experimental computer programs will be designed to determine the feasibility of obtaining a Predictive Epizoology model, with the data available.

7. While additional collection data is available for the years 1951-54 and epizoological diagnosis data for the years 1951-57, no funds are available at present for codification of these data. While it may be possible to arrive at some conclusions based on 6 1/2 years of data, the additional 6 1/2 years of data presently uncodified, possibly would double the chances of success and would surely increase the accuracy of any such operation since it has been proven by the system of correlative analysis that some, if not all, of the diseases show an incidence rate that varies in a cyclic manner, with a wide deviation, i.e., possibly ten years in some cases, between the peaks of cycles. Therefore, it is believed that every effort should be expended to codify for electric computation the remaining uncodified data for inclusion in the possible electronic derivation of a model.

B. Correlative Analysis:

1. Pending completion of electronic computation of a Predictive Analysis model, a system of correlative analysis has been instituted consisting of graphical interpretations of incidence rate in the various zones involved for the diseases of interest for the calendar year 1963.

2. For the purpose of determination of the overall trends of incidence of disease, the various separate areas have been integrated into zones, as follows:

a. Inner, or Zone I: The area of northwestern Utah upon which there has been no grazing since 1949.
b. Intermediate, or Zone II: Those areas contiguous to or easily influenced by Zone I.
c. Distance Control, or Zone III: Areas reasonably similar to Zone I, but lying at such a distance from it as not to be generally interrelated.
d. Transmountain, or Zone IV: Areas separated from the Intermediate, or Zone II, by a major mountain range.
e. Complete or Double Check Control, Zone V: Areas located behind mountain ranges and more than 100 miles from the center of Zone I., e. g., a completely different region containing some similar biotic communities.

3. Segregation of the specimens into general groups of rodents, birds, and lagomorphs for the purpose of correlative analysis was instituted during this year. These groups are handled separately for analysis purposes. However, since all animals in a zone have been treated together in past years, this practice is also employed for the sake of continuity.

4. Following this discussion the diagnostic results by groups, disease, diagnostic method, and zone, are presented graphically by months, with the actual results printed just below the monthly axes (Figs. E-1 through E-45). Here, each disease is considered for endemicity and epizoological incidence, first on the basis of serological examination and later on the basis of tissue and ectoparasite analysis.

a. Q fever: (Serological) (Figs. E-1 through E-4).

(1) Q fever continued to be evident in the rodents of all zones with the incidence rate following general seasonal cyclic trends at relatively low levels being more prevalent in the spring and fall and reaching its maximum in Zones II and III, zones in which maximum domestic animal density is observed.

(2) Among the lagomorphs this disease was the most prevalent in Zone I and was not found in Zone IV by sera analysis, although a high rate was noted in Zone III in January, and a low rate during the late spring in Zone II. The incidence rate and sample sizes in lagomorphs were not such as to provide marked evidence of a cyclic condition, but when all animals are considered, the cyclic condition is apparent. However, levels were not sufficiently high to indicate the beginning or occurrence of an epizootic.

b. Brucellosis: (Serological) (Figs. E-5 through E-8).

(1) This disease appeared as endemic in rodents of Zone I, reaching an epizootic peak in August and dying out in the fall. While no incidence was apparent in rodents in the other zones during this year, its past occurrence in these zones probably simply indicates a low level in these zones for rodents, and not an elimination of the disease.

(2) In lagomorphs the disease was more prevalent, reaching about the same relative epidemicity in Zone III in January, February, and November; in Zones II and IV in September, and in Zone I in October. Thus, it may be considered that local epizootics in lagomorphs occurred all over the region during the autumn of 1963 and the winter of 1963-64. This is the time of the greatest animal population in the area.

(3) No evidence of this disease was found in the birds or animal ectoparasites during the year. Past experience indicates that when little or no evidence is found in ectoparasites, the general level of the disease incidence rate is low.

(4) The general level of this disease in all native animals in the area is lower than in previous years, indicating a low point in the general cyclic trend noted over the years studied.

c. Plague: (Serological) (Figs. E-9 through E-12)

Endemicity in small areas other than the Deep Creek Mountains was noted, but was of such a low order and so scattered as not to establish any trends in any type of animals.

d. Psittacosis: (Serological) (Figs. E-13 through E-16).

(1) Although present in rodents in all zones except IV and V, the level in these animals is low, being apparent only in a spring and fall cycle.

(2) In lagomorphs the incidence rate was considerably higher, but not alarmingly so, generally reaching one peak per year.

(3) When all of the animals are considered, the spring and fall cyclic condition is evident, though no epizootics were discovered.

e. Tularemia: (Serological) (Figs. E-17 through E-20).

(1) Practically no tularemia in rodents was noted by serological methods during the year, showing only in Zone I in January, Zone II in October, and Zone III in May, and then only in minute amounts.

(2) Among lagomorphs the incidence rate was even lower, appearing only in Zone II in May.

(3) No evidence was determined in birds in any zone, and thus the overall rate would have been miniscule, except for the 4 positive deer taken in January, 1963. However, since deer had not been included in collections of previous years to any great extent, the month of January, 1963 must be discounted when comparisons are attempted.

f. Rocky Mountain spotted fever: (Serological) (Figs. E-20 through E-28).

(1) This disease occurred in all zones in rodents in a rather stable cyclic manner, except for Zone II in July. In this month, while the incidence was low in Zone I, it soared to a high for the year in Zone II. Unfortunately, Zones III and IV were not sampled during this particular month so no accurate comparison may be made. However, during the ensuing months the drop tends to indicate that this flare-up may have been a late seasonal affair.

(2) The extremely high incidence of RMsf among the lagomorphs of all zones generally indicates an epizootic.

g. Q fever and Brucellosis: (Tissue) Figs. E-25 through E-32).

(1) The incidence rate based on tissue analysis is so low in both of these diseases in all zones as to be meaningless for the purpose of correlative analysis.

(2) However, the occurrence of a single Brucellosis positive out of 71 samples of rodents in Zone I in September (Fig. E-29), and a similar one for Q fever out of 211 samples in Zone I in February does confirm that these diseases are still endemic.

(3) The zero incidence rate here and in the other following situations does not imply that the disease is absent but that the incidence rate is so low as not to be determined when sample size is held to the 200 to 300 sample range.

h. Psittacosis: (Tissue) (Figs. E-33 through E-36), and Rocky Mountain spotted fever: (Figs. E-41 through E-44).

(1) The absence of confirmation by tissue analysis of the incidence rate as determined by serological methods for these diseases posed a problem which is specifically discussed under the ES Phase.

(2) The data on tissue analysis considered on these graphs for these diseases cannot then be used for correlative analysis until further research determines their overall validity in relation to endemicity.

i. Tularemia: (Tissue) (Figs. E-37 through E-40).

(1) The incidence rate of this disease in lagomorphs indicates continued endemicity, while the zero rate in rodents is not particularly significant.

(2) The rate as calculated for all mammals is somewhat below the 0.5% that has been determined to be the yearly average rate, and thus denotes a low point in the disease cycle.

j. Ectoparasites: (Fig. E-45).

The zero incidence rate for all species as calculated on the basis of ectoparasite analysis for all diseases of interest simply confirms the fact that while endemicity probably is continuing, ecological conditions were such during calendar year 1963 that the incidence of all the diseases was, in general, rather low.

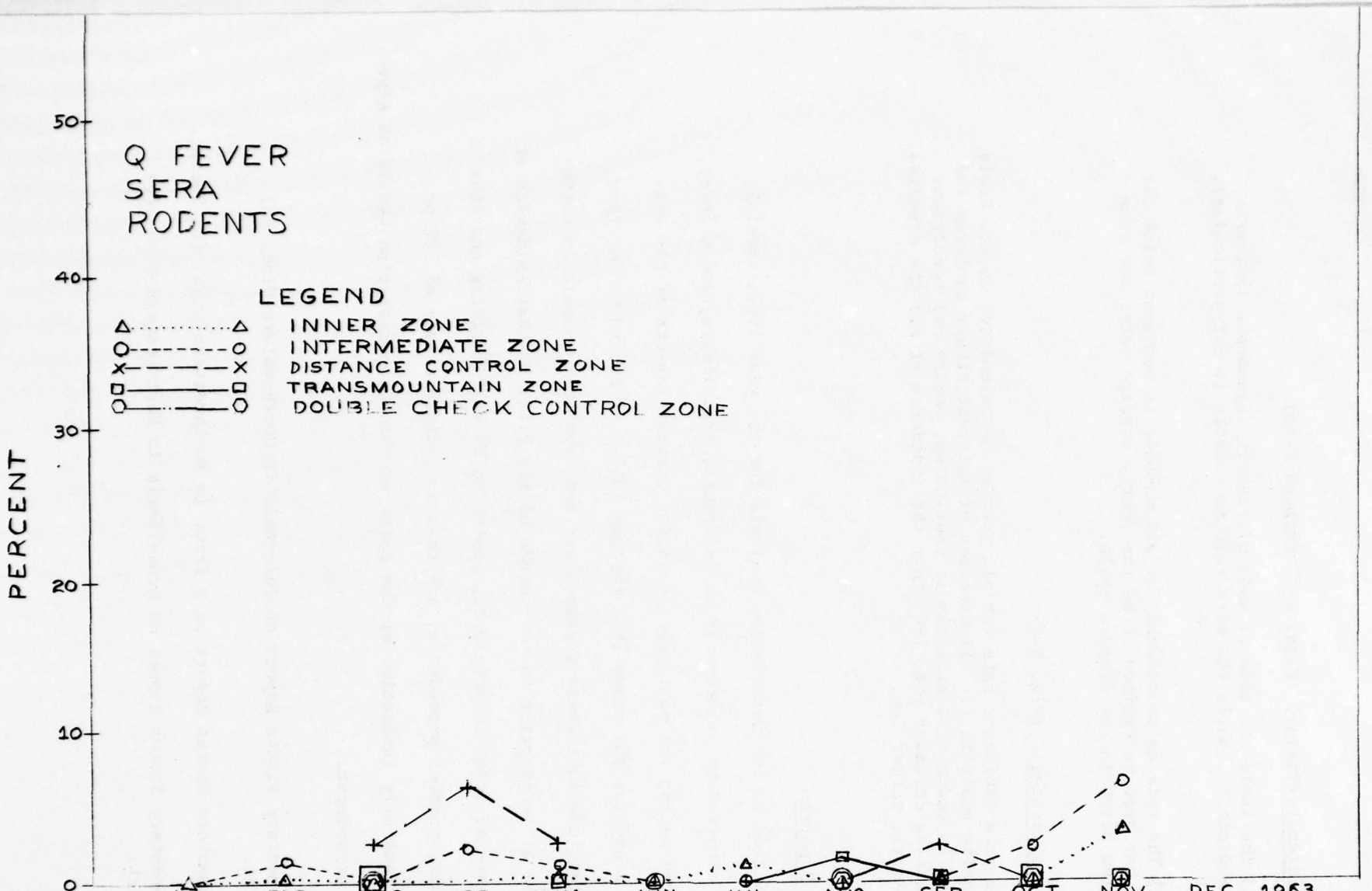
C. Special Reports

In addition to the Correlative Analysis for the year 1963, special reports as required by Priority IV on Tularemia, Brucellosis, and Q fever, were prepared during the past year, covering special aspects of the epizoological study for the years 1951 through 1963. As titled below, they generally conclude that these diseases are and have been endemic in northwestern Utah at least prior to the decade of the fifties; that epidemics of these diseases at least in this area, appear to be self-limiting and thus do not require control procedures; and that an incidence rate of 10% or greater is generally indicative of the point at which consideration should be given to control procedures.

a. Supplementary Status Report on Tularemia in Northwestern Utah. (U) Secret.

b. Supplementary Status Report on Q fever in Northwestern Utah. (U) Secret.

c. Supplementary Status Report on Brucellosis in Northwestern Utah. (U) Secret.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
△	0/1	1/211	0/26		1/176	0/1	4/281	0/10	0/71	0/72	3/98
○		1/70	0/37	1/40	1/120	0/4	0/146	0/39	0/114	2/84	2/30
+			2/79	3/45	4/163	0/3		0/36	4/162	0/9	0/3
□			0/64		0/104			1/75	0/37	0/0	
○			0/26					0/2		0/215	0/13

FIGURE E-1

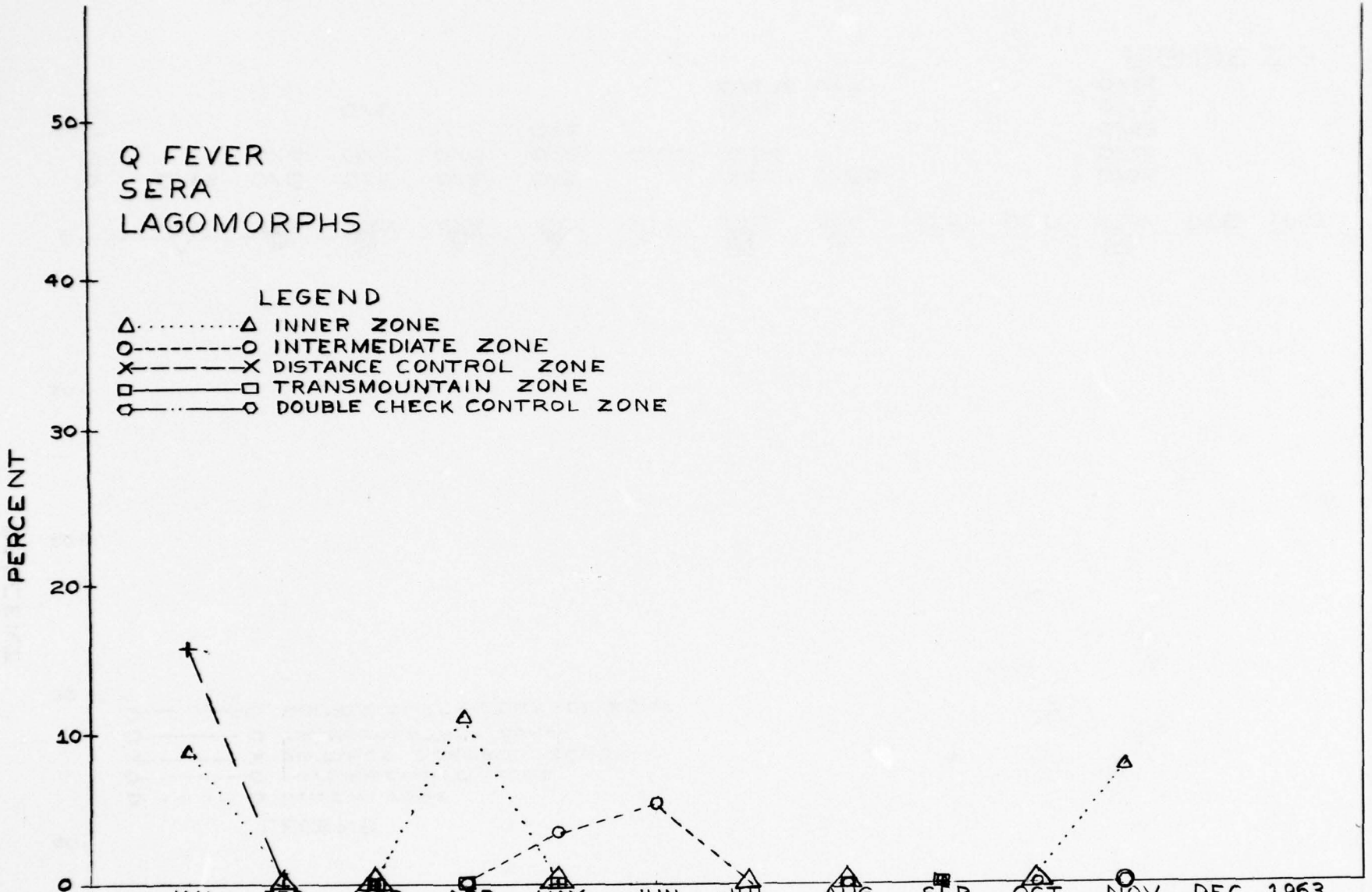

Q FEVER
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 1/11 0/10 0/6 2/18 0/7 0/28 0/24 1/12
O 0/3 0/23 1/27 1/17 0/58 0/24 0/13 0/25
+ 1/6 0/23 0/8 0/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
Q 0/16

FIGURE E-2

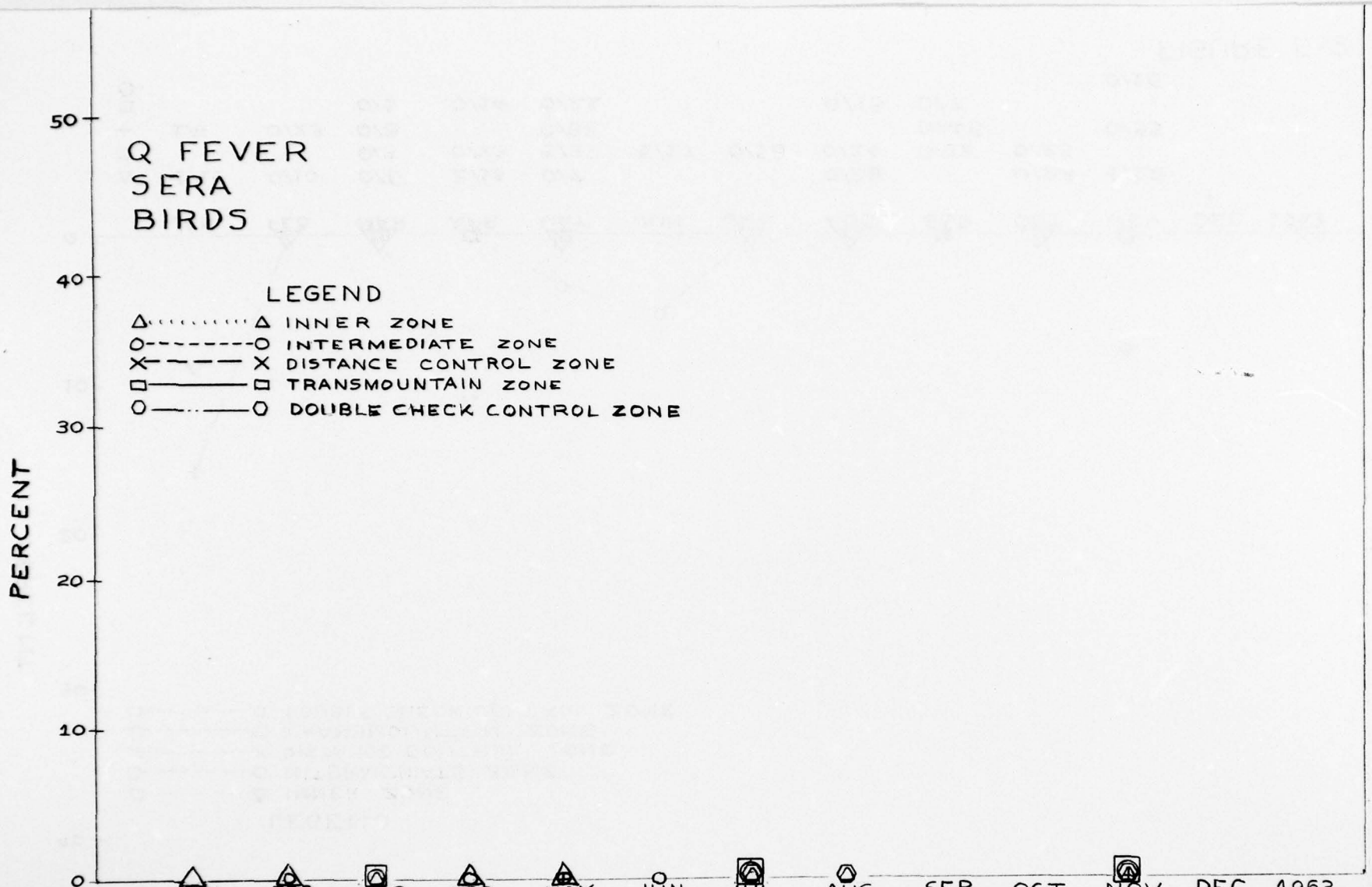
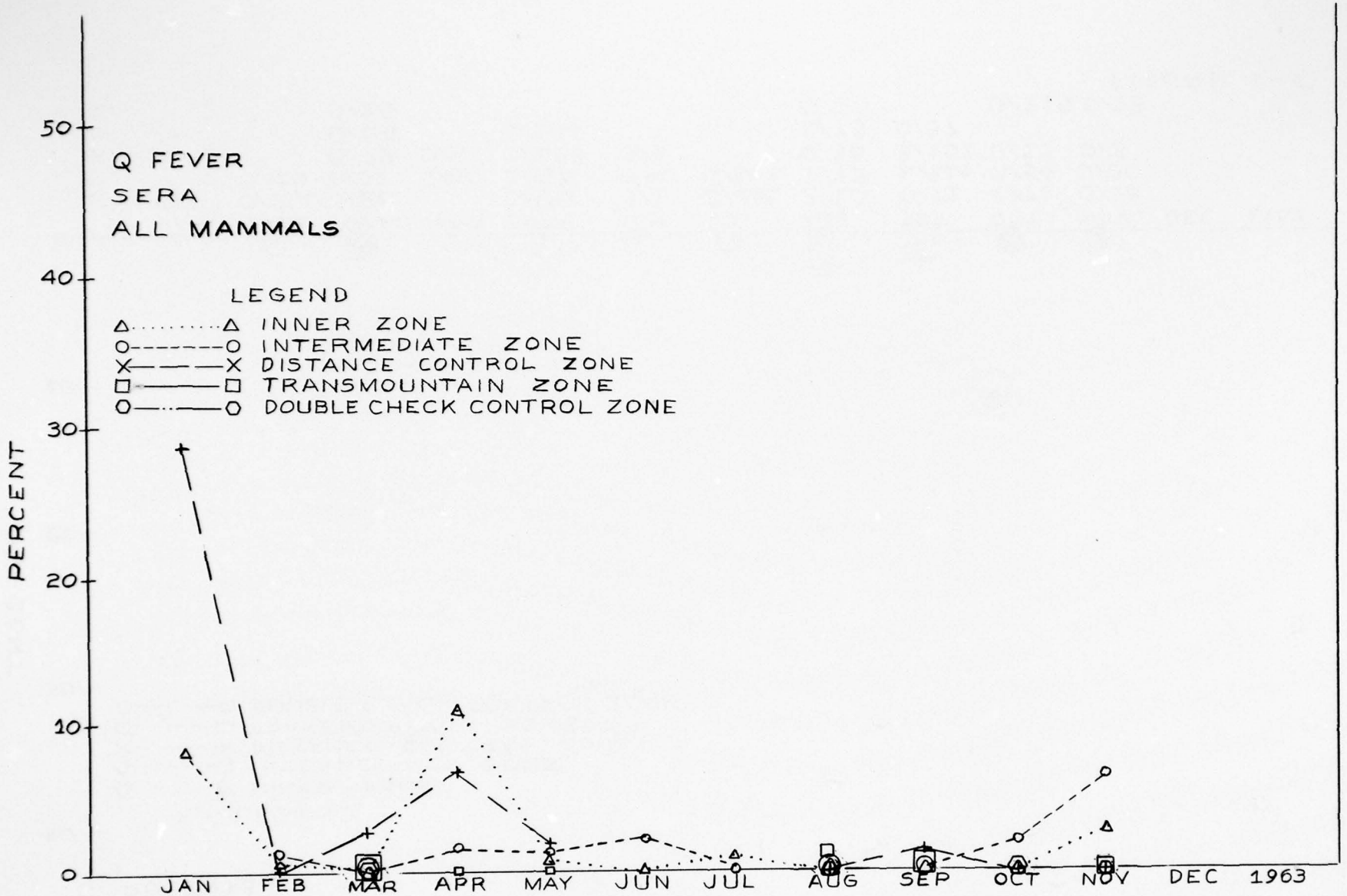

Q FEVER
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/13
0/6
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/35
0/11
0/64
0/9
0/176
0/66
0/7
0/31
0/0
0/13
0/2
0/11

FIGURE E-3



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
△	1/12	1/221	0/32	2/18	1/183	0/1	4/350	0/56	0/71	0/96	4/141
○		1/70	0/40	1/63	2/188	1/51	0/118	0/63	0/127	2/109	2/30
+	4/14	0/23	2/87	3/45	4/195			0/36	4/208	0/9	0/71
□			0/65	0/68	0/125			1/91	0/44		0/2
◇			0/26					0/2		0/215	0/40

FIGURE E-1

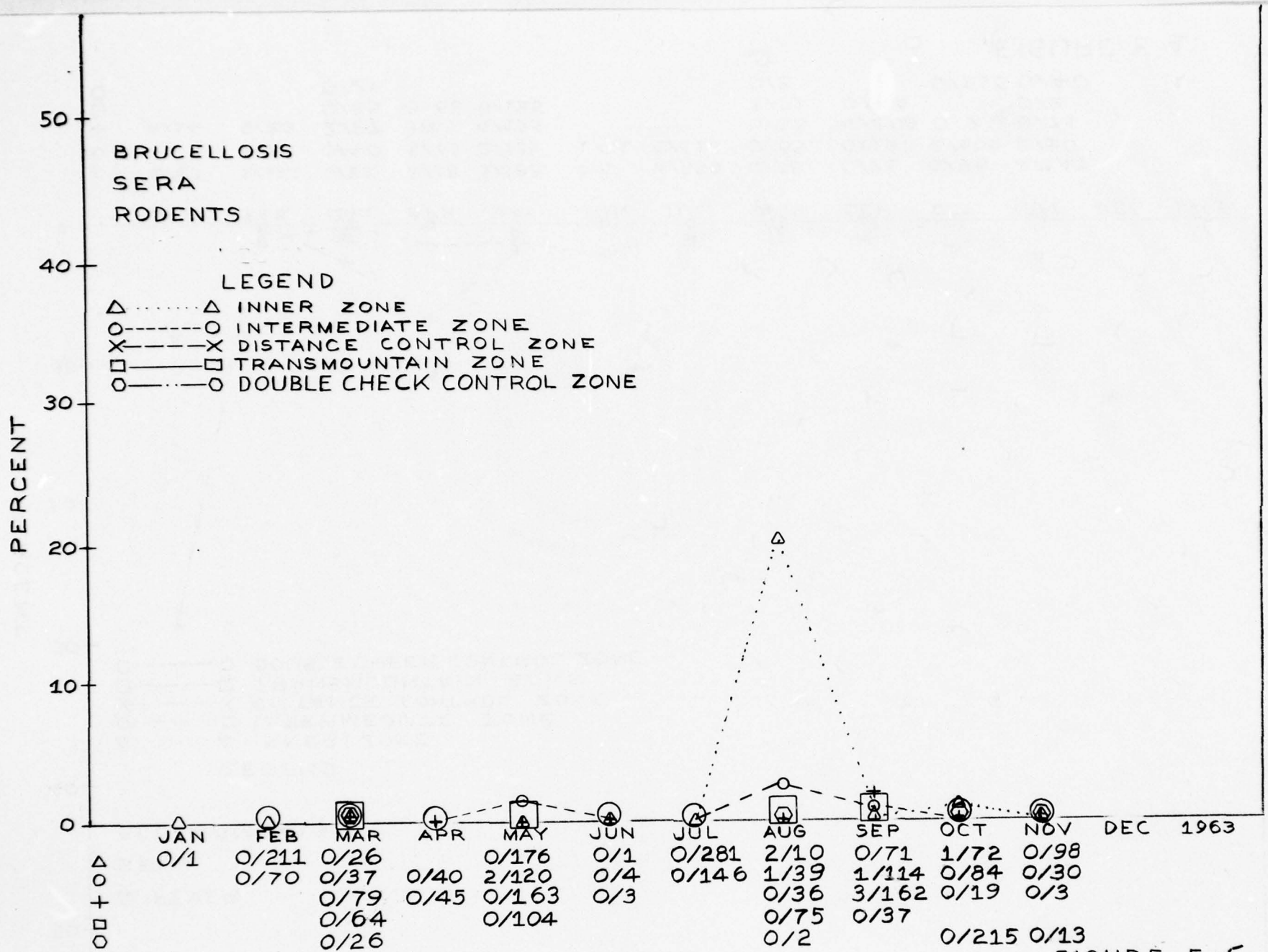

BRUCELLOSIS
SERA
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/1
0/211
0/70
0/26
0/37
0/79
0/64
0/26
0/40
0/45
0/176
2/120
0/163
0/104
0/1
0/4
0/3
0/281
0/146
2/10
1/39
0/36
0/75
0/2
0/71
1/114
3/162
0/37
1/72
0/84
0/19
0/215
0/98
0/30
0/3
0/13

FIGURE E-5

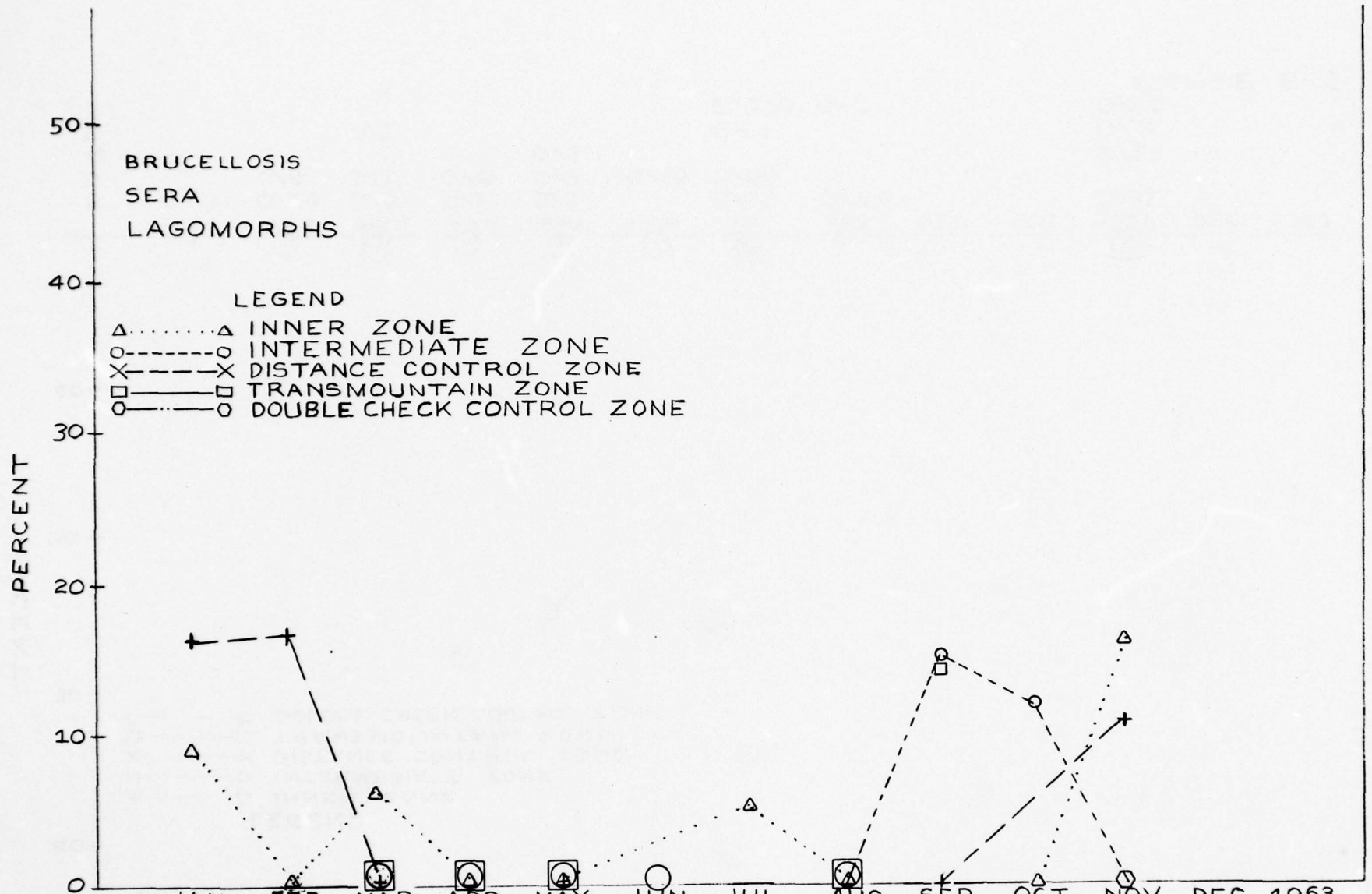

BRUCELLOSIS
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
△ 1/11 0/10 0/6 0/18 0/7 3/58 0/28 0/24 2/12
○ 0/3 0/23 0/27 0/17 0/24 2/13 3/25
+ 1/6 4/23 0/8 0/32 0/46 6/55
□ 0/1 0/14 0/21 0/16 1/7
○ 0/16

FIGURE E-6

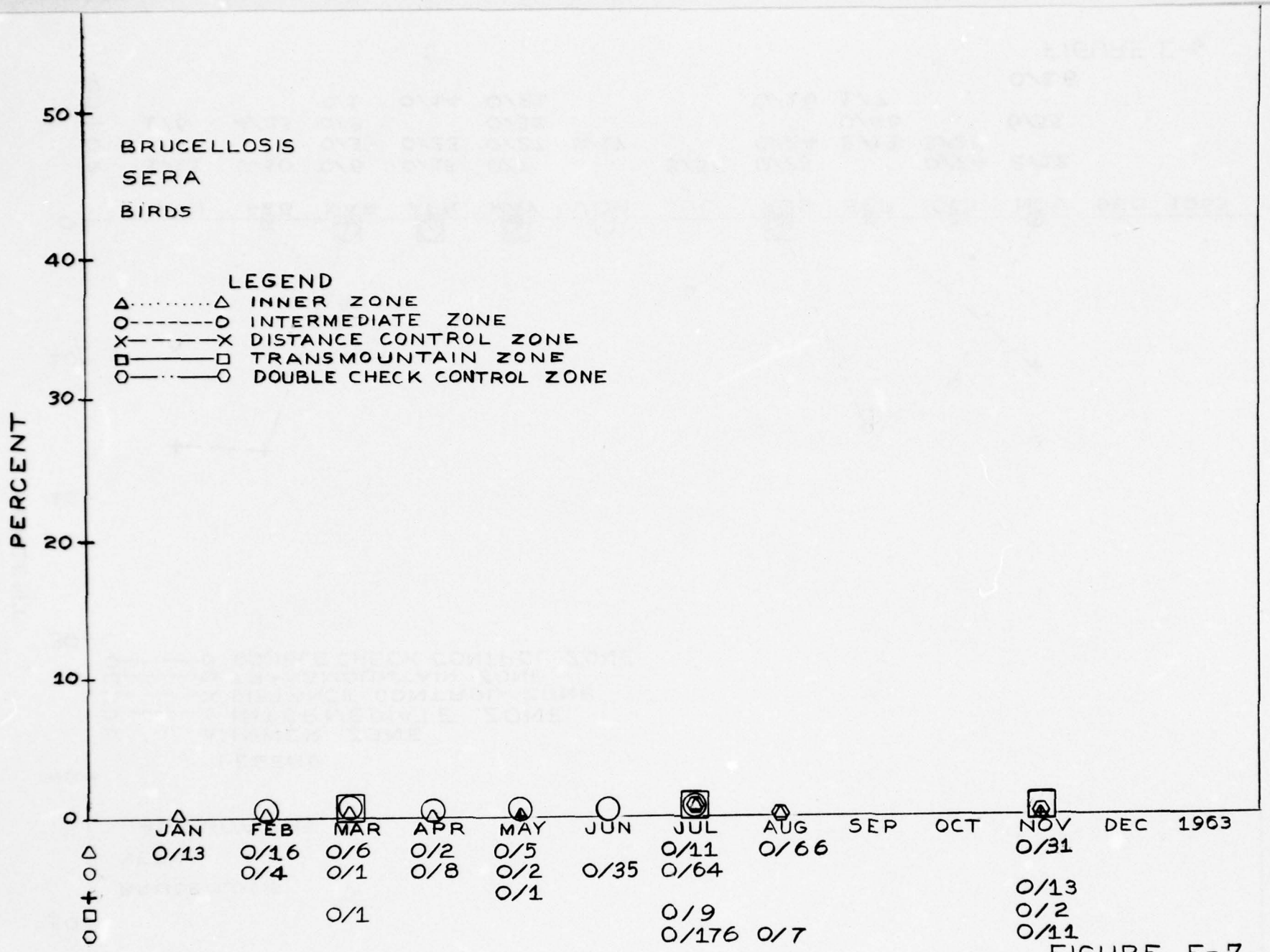
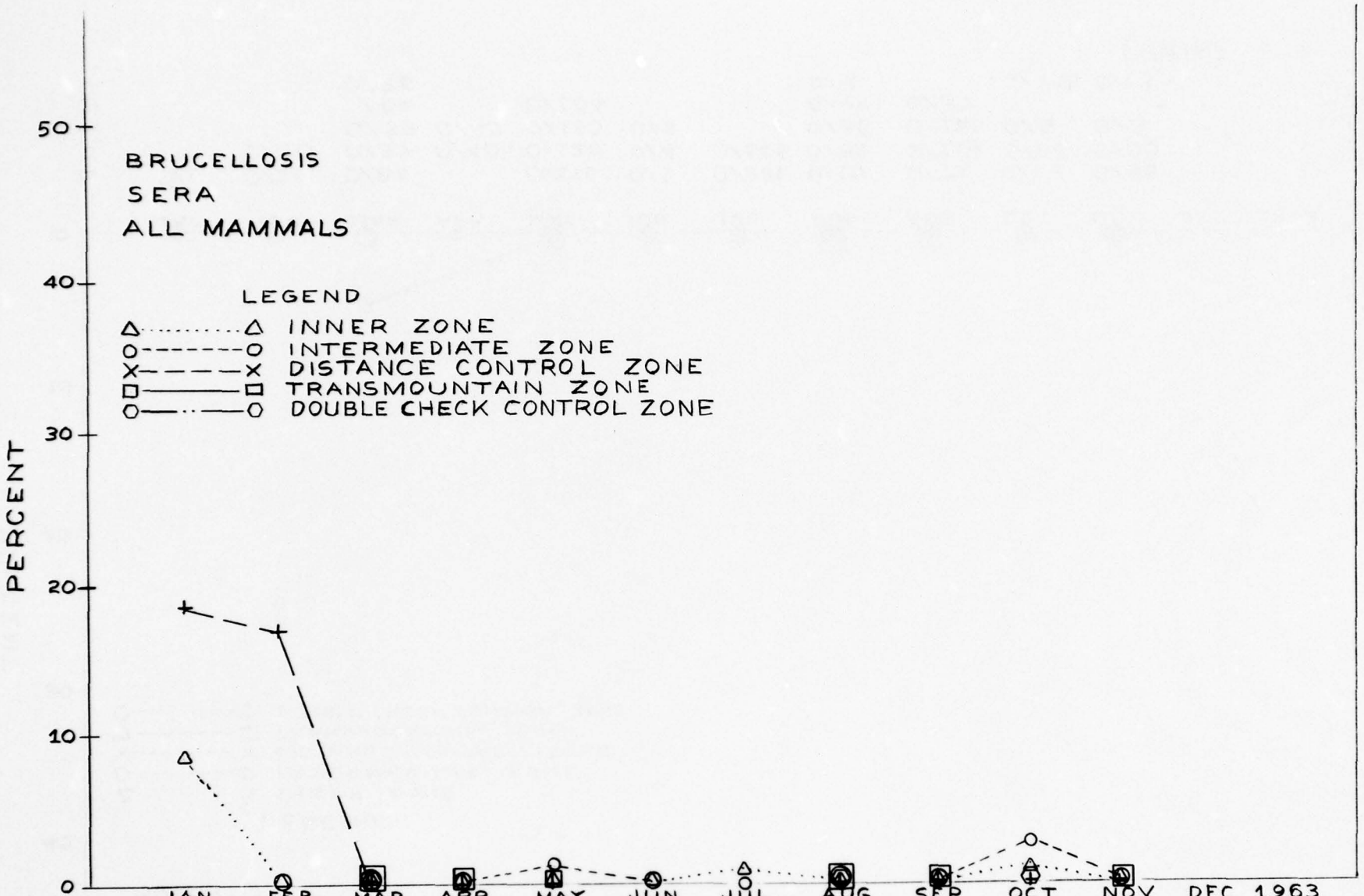

BRUCELLOSIS
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/13
0/16
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/35
0/11
0/64
0/9
0/176
0/66
0/7
0/31
0/13
0/2
0/11

FIGURE E-7



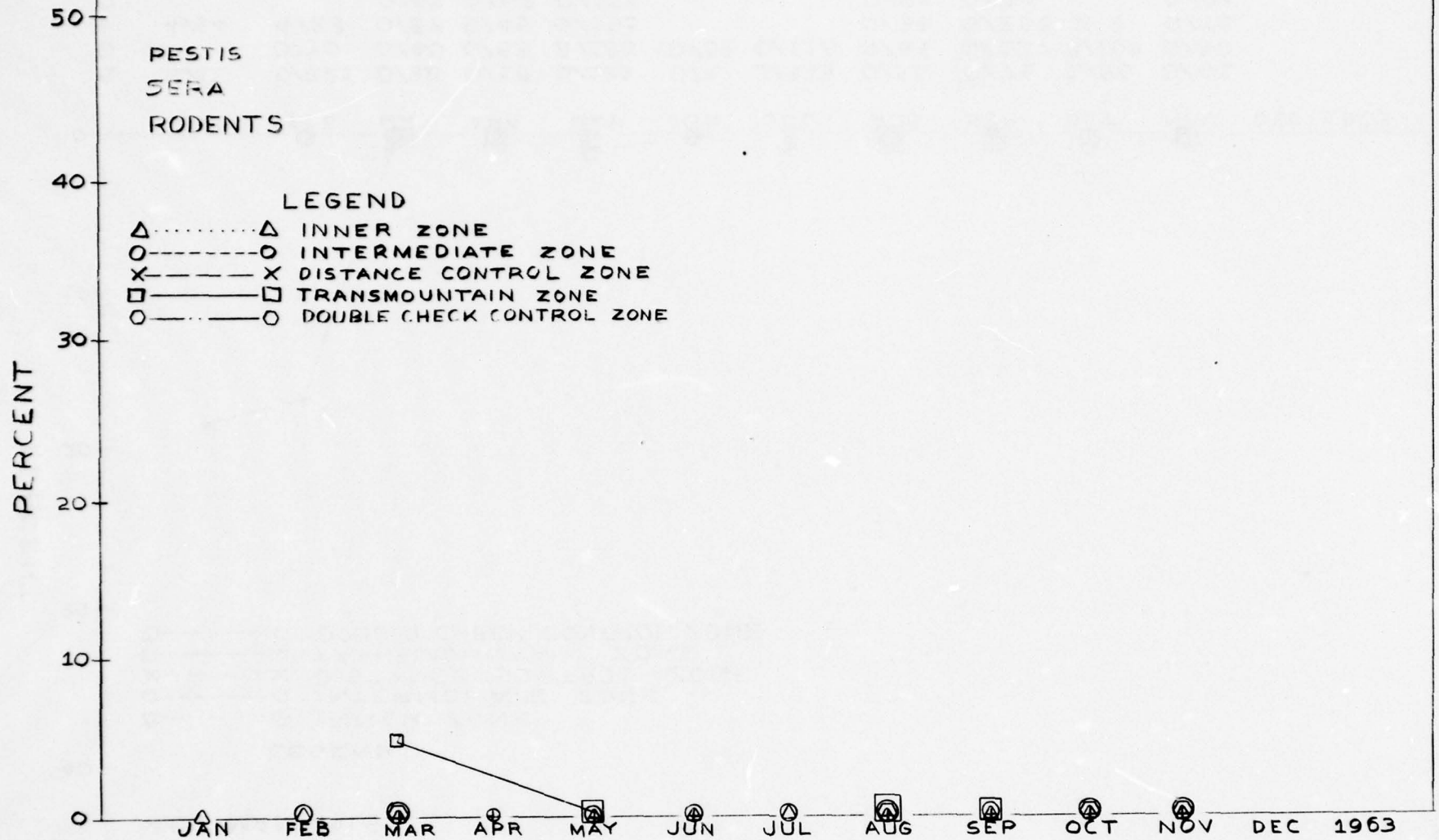
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
△	1/12	0/221	0/32	0/18	0/183	0/1	3/339	0/56	0/71	1/96	0/41
○		0/70	0/40	0/63	2/188	0/51	0/118	0/63	0/127	3/109	0/30
+	4/14	4/23	0/87	0/45	0/195			0/36	0/208	0/9	0/71
□			0/65	0/68	0/125			0/91	0/44		0/21
○			0/26					0/2		0/215	3/40

FIGURE E-8

PESTIS

SERA

RODENTS



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
△	0/1	0/211	0/26		0/176	0/1	0/281	0/10	0/71	0/72	0/98	
o		0/70	0/37	0/40	0/120	0/4	0/146	0/39	0/114	0/84	0/30	
+			0/79	0/45	0/163	0/3		0/36	0/162	0/9	0/3	
□			/64		0/104			0/75	0/37			
o			0/26					0/2		0/215	0/13	

FIGURE E-9

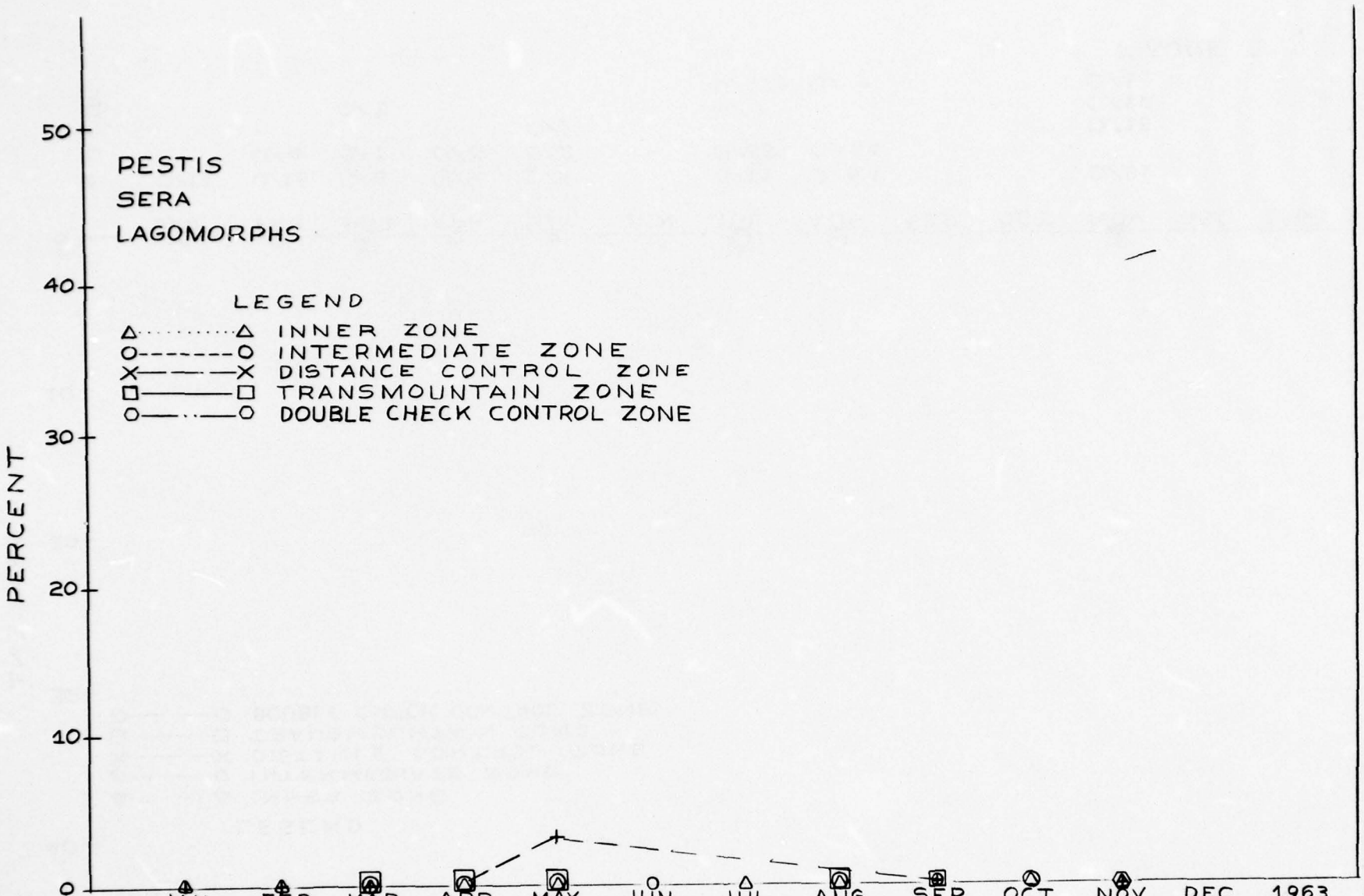

PESTIS
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/24 0/12
○ 0/3 0/23 0/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 1/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
○ 0/16

FIGURE E 10

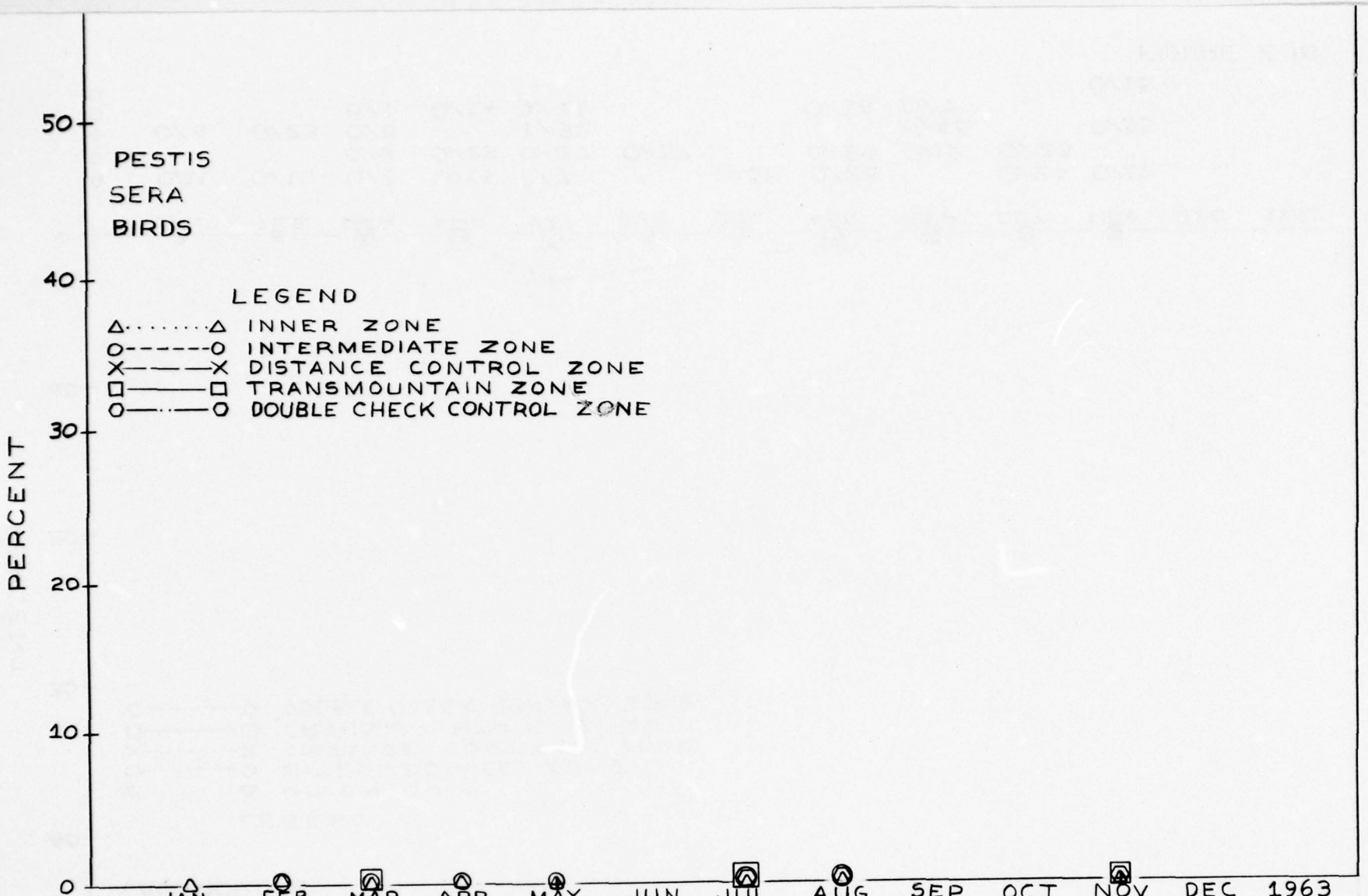

PESTIS
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/13
0/16
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/11
0/35
0/9
0/176
0/66
0/64
0/7
0/31
0/13
0/12
0/11

FIGURE E 11

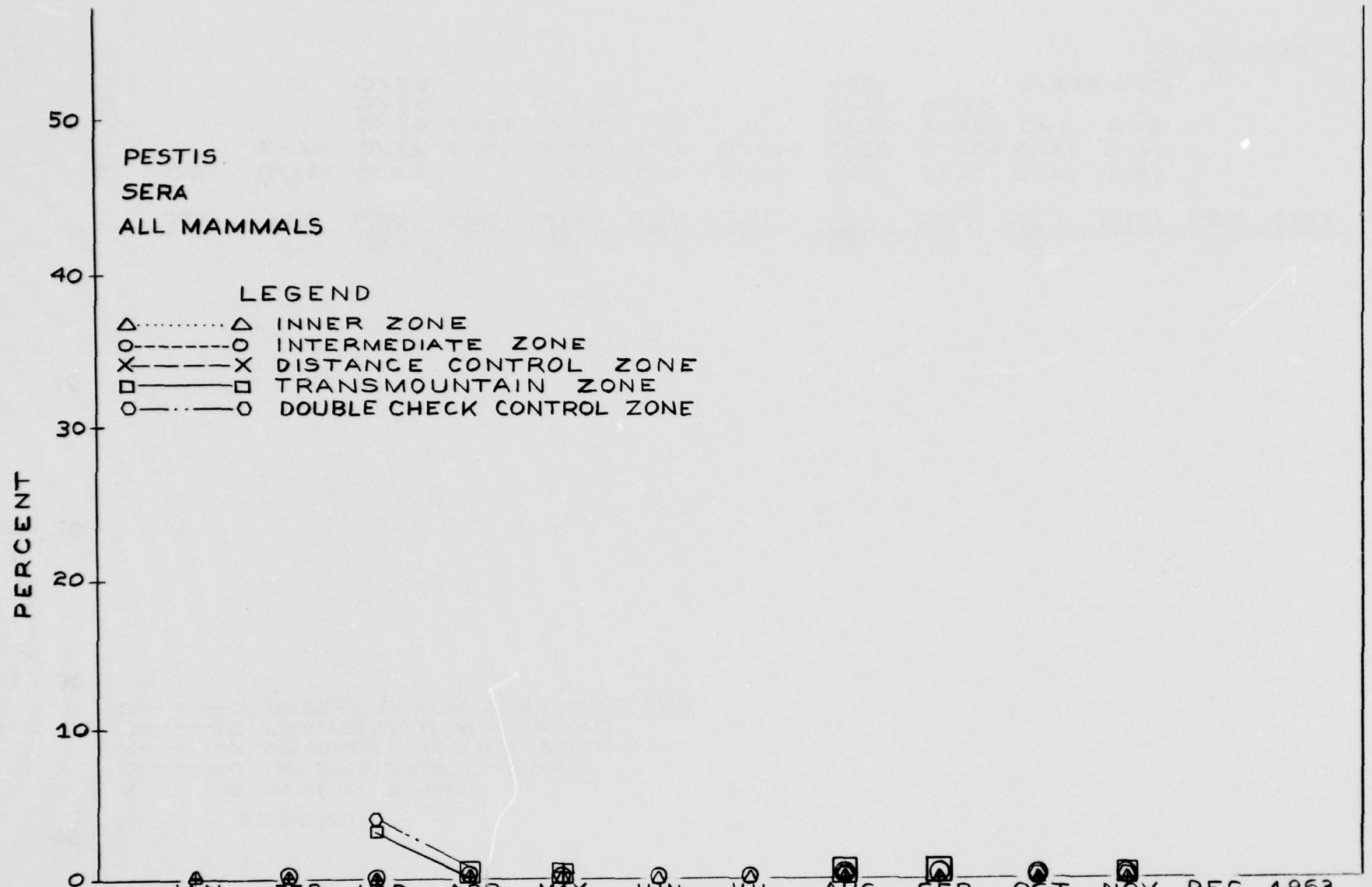

PESTIS
SERA
ALL MAMMALS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/12 0/221 0/32 0/18 0/183 0/1 0/339 0/56 0/71 0/96 0/141
○ 0/70 0/40 0/63 0/188 0/51 0/118 0/63 0/127 0/109 0/30
+ 0/14 0/23 0/87 0/45 1/195 0/36 0/208 0/9 0/71
□ 2/65 0/68 0/125 0/91 0/44 0/21
◇ 1/26 0/2 0/215 0/40

FIGURE E-12.

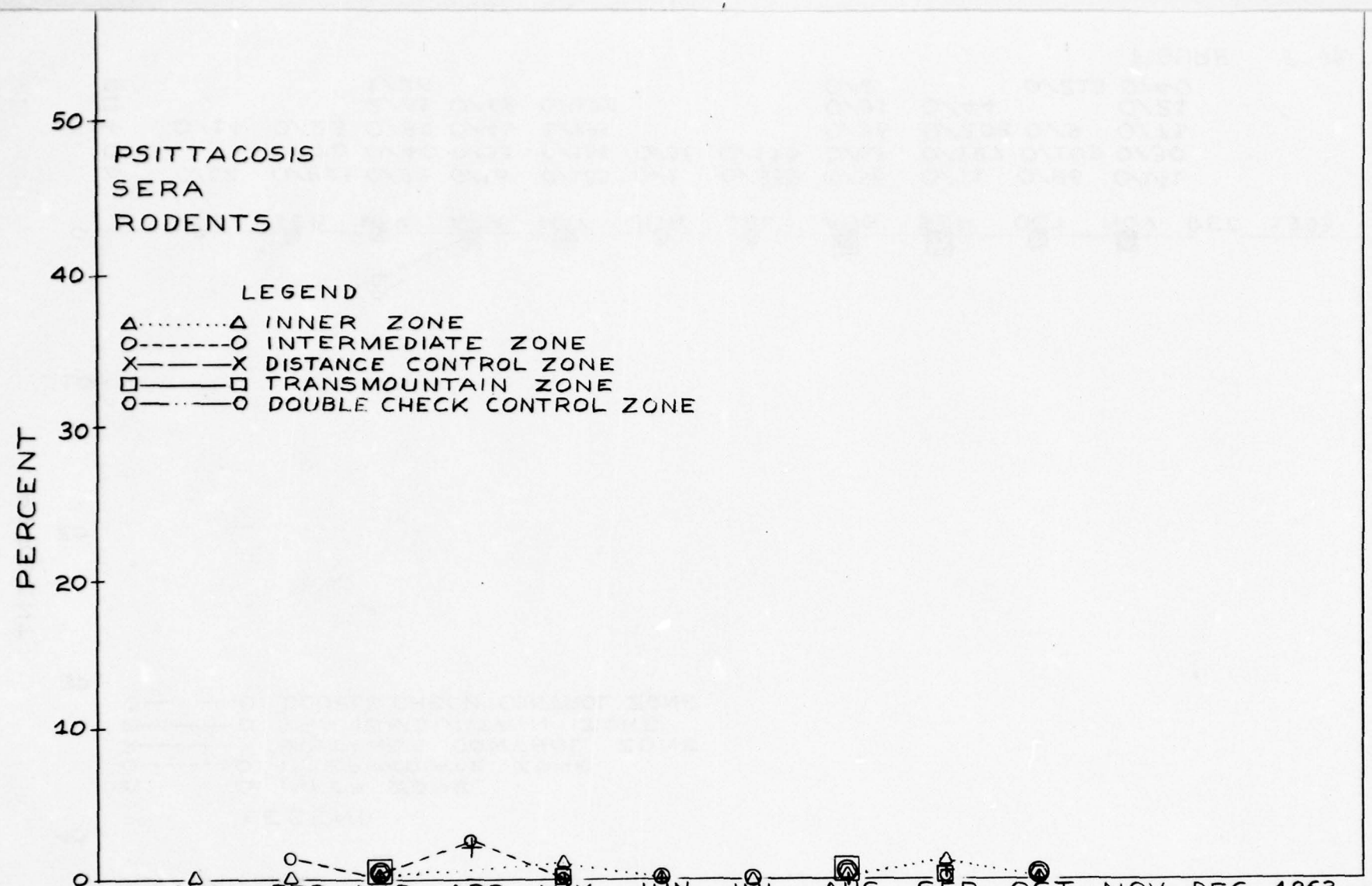

PSITTACOSIS
SERA
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 0/1 0/211 0/26 2/176 0/1 0/281 0/10 1/71 0/72 0/98
O 1/70 0/37 1/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 1/45 0/163 0/3 0/36 1/162 0/9 0/3
□ 0/64 0/104 0/75 0/37
O 0/26 0/2 0/215 0/13

FIGURE E-13

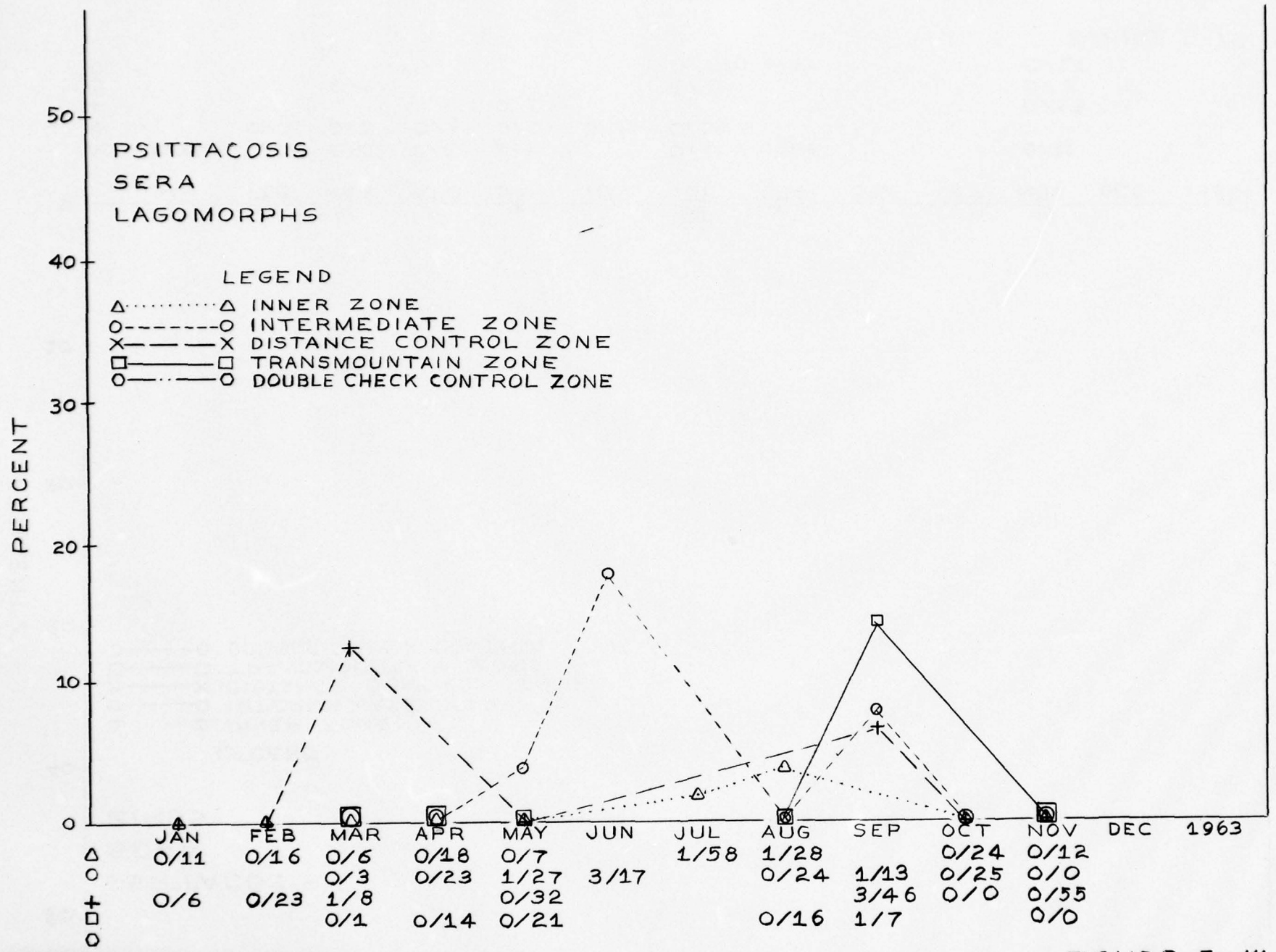

PSITTACOSIS
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/11
0/16
0/6
0/3
1/8
0/1
0/18
0/23
0/14
0/7
1/27
0/32
0/21
3/17
1/58
1/28
0/24
0/16
1/13
3/46
1/7
0/24
0/25
0/0
0/12
0/0
0/55
0/0

FIGURE E-14

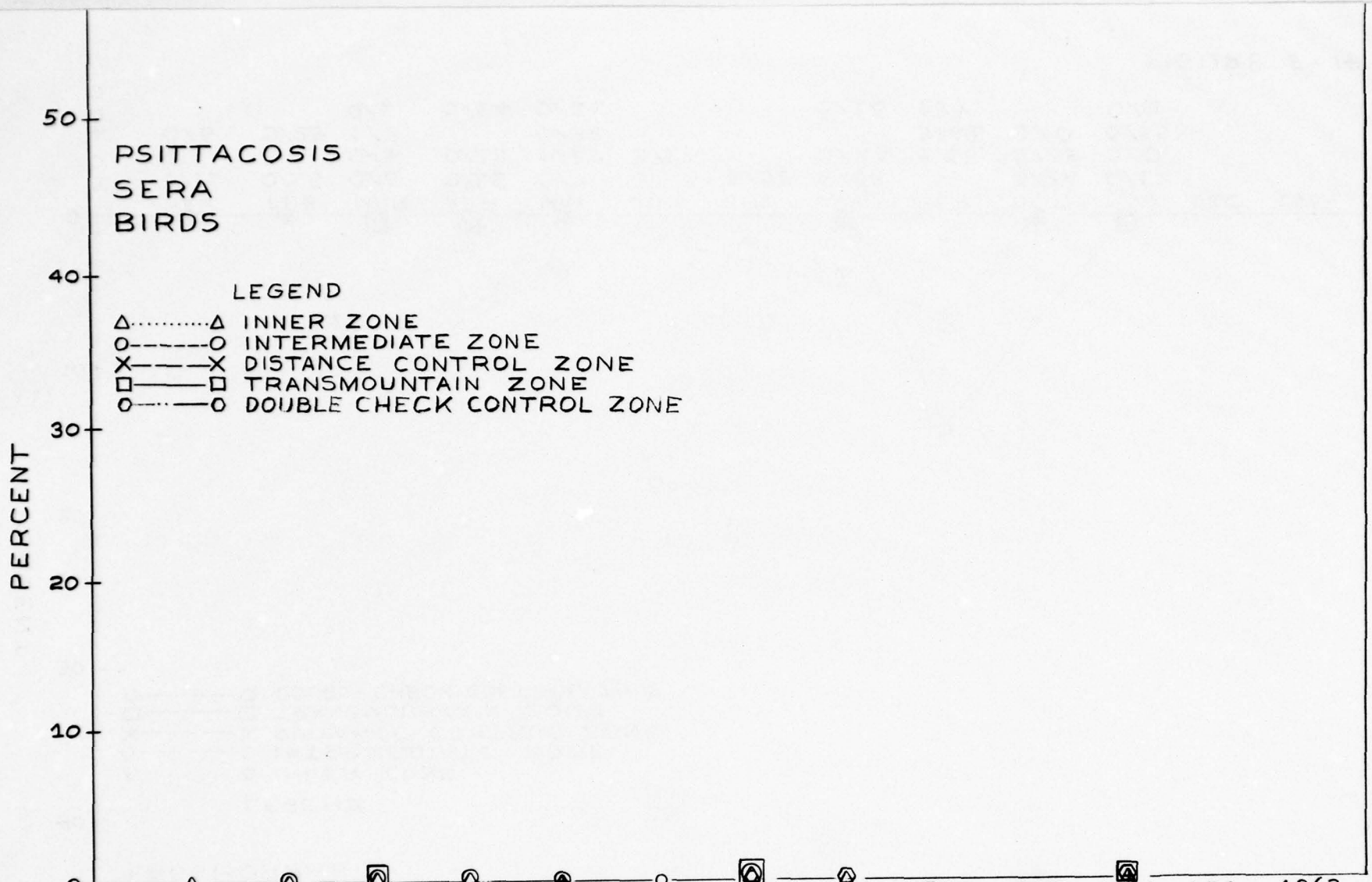
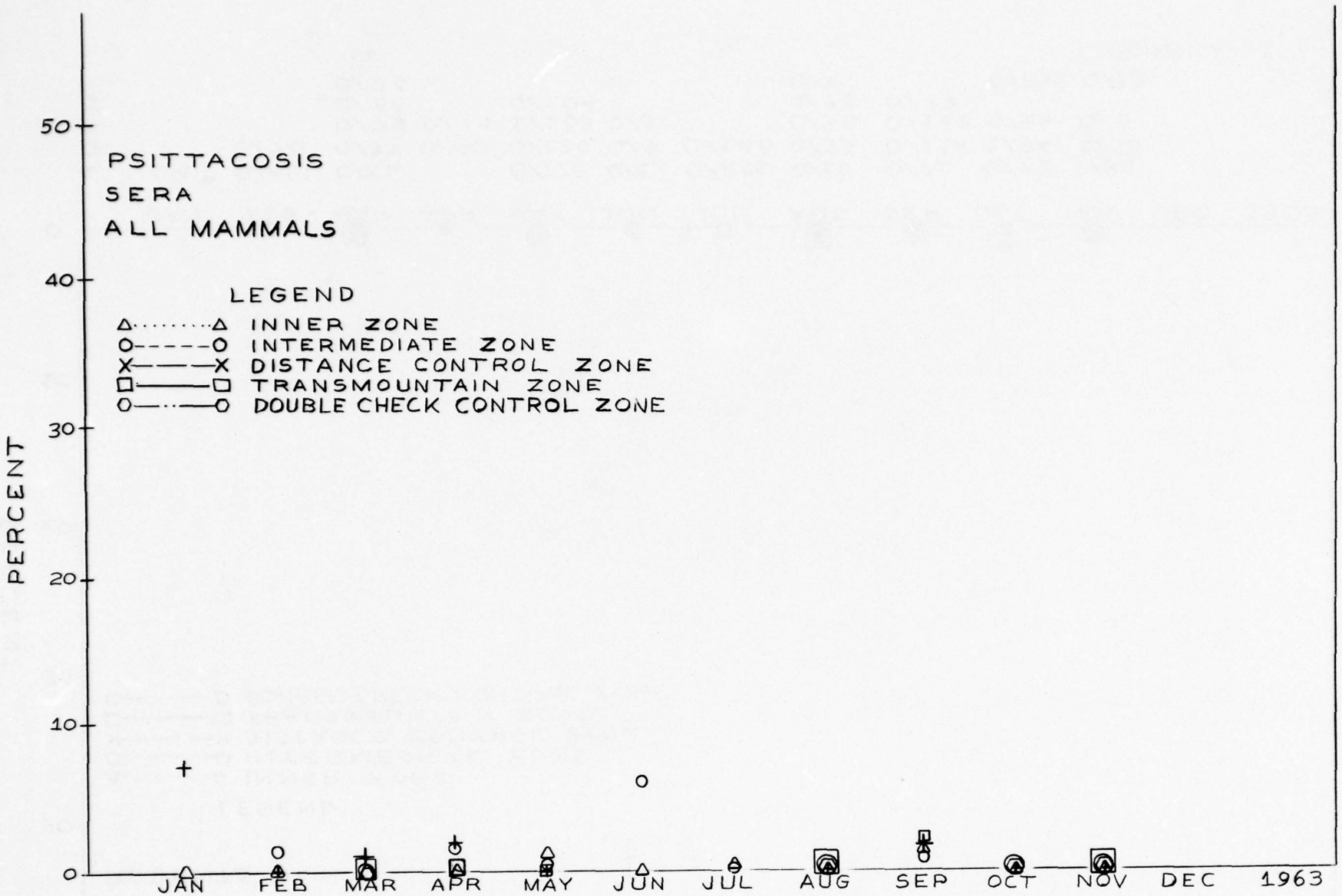

PSITTACOSIS
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/13
0/16
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/35
0/11
0/64
0/9
0/176
0/66
0/7
0/31
0/13
0/2
0/11

FIGURE E-15



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
△	0/12	0/221	0/32	0/18	2/183	0/1	1/339	0/56	1/71	1/96	0/141
o		1/70	0/40	1/63	1/188	3/51	0/118	0/63	1/127	1/109	0/30
+	1/14	0/23	1/87	1/45	0/195			0/36	4/208	0/9	0/71
□			0/65	0/68	0/125			0/91	1/44		0/2
O			0/26					0/2		0/215	0/40

FIGURE E-16

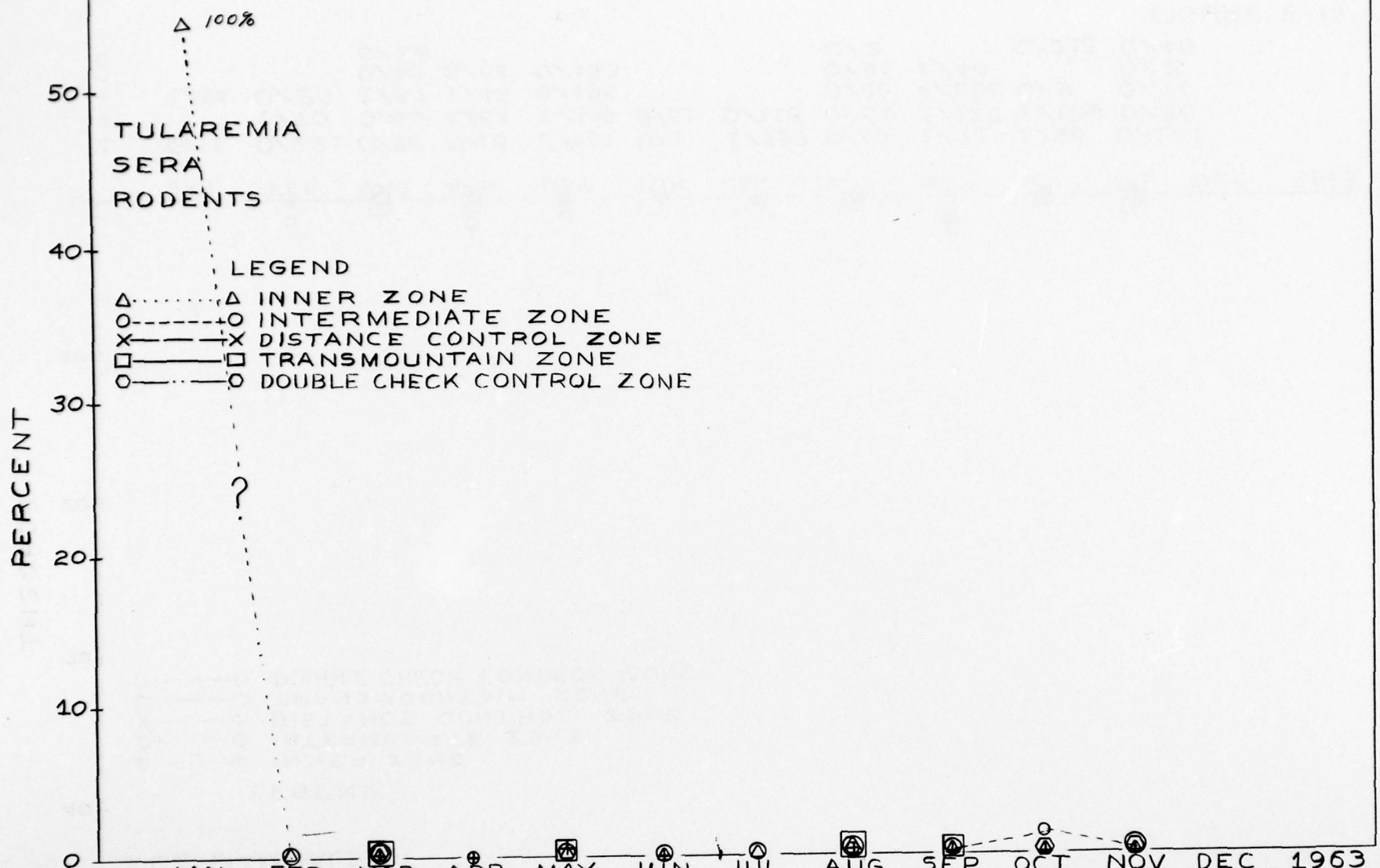

100%
50
40
30
20
10
0
PERCENT
TULAREMIA
SERA
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
?
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
1/1
0/211 0/70
0/26 0/37 0/79 0/64 0/26
0/40 0/45
0/176 0/120 1/163 0/104
0/1 0/4 0/3
0/281 0/146
0/10 0/39 0/36 0/75 0/2
0/71 0/114 0/162 0/37
0/72 1/84 0/19 0/215
0/90 0/30 0/3 0/13

FIGURE E-17

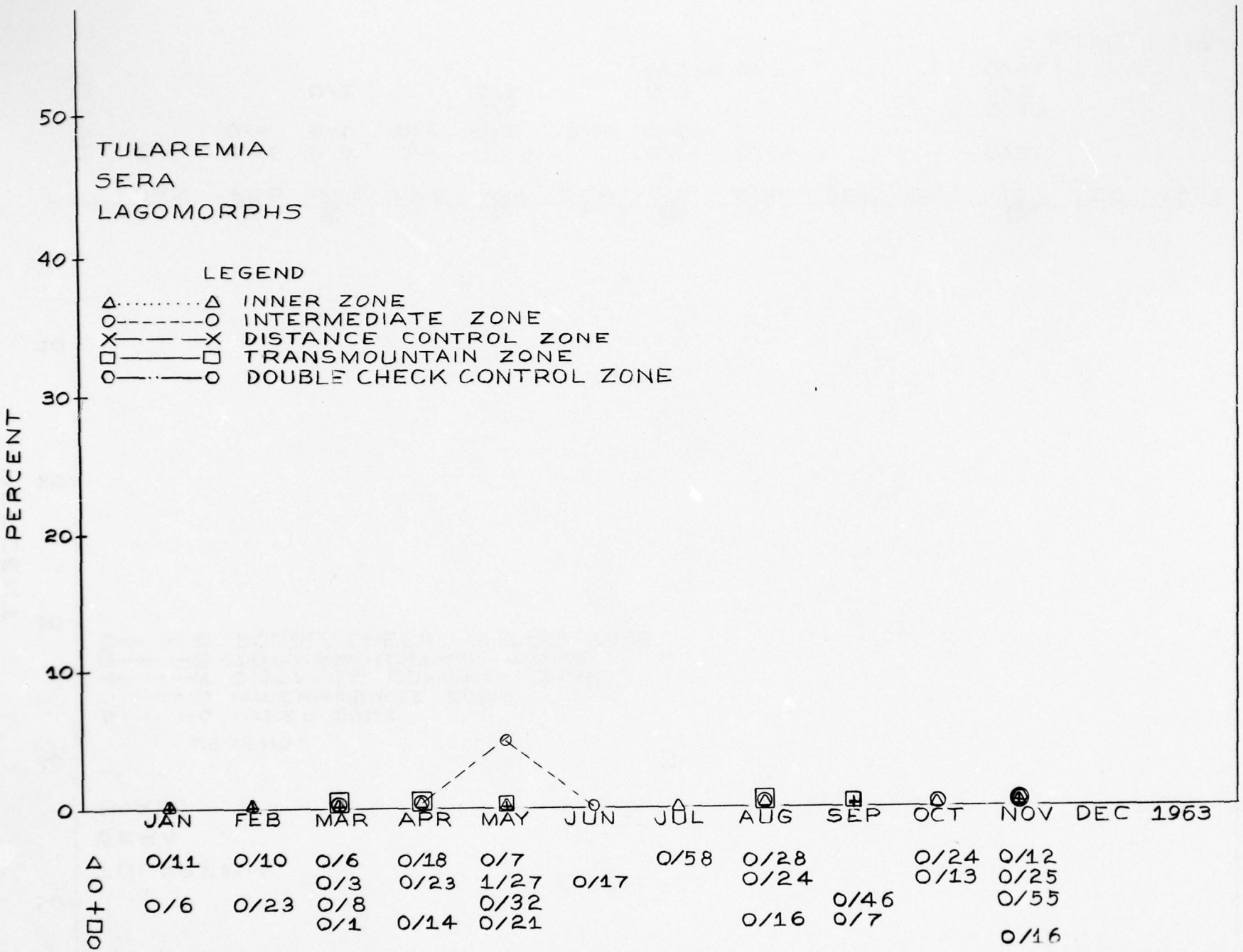

TULAREMIA
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/24 0/12
0 0/3 0/23 1/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 0/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
0 0/16

FIGURE E- 18

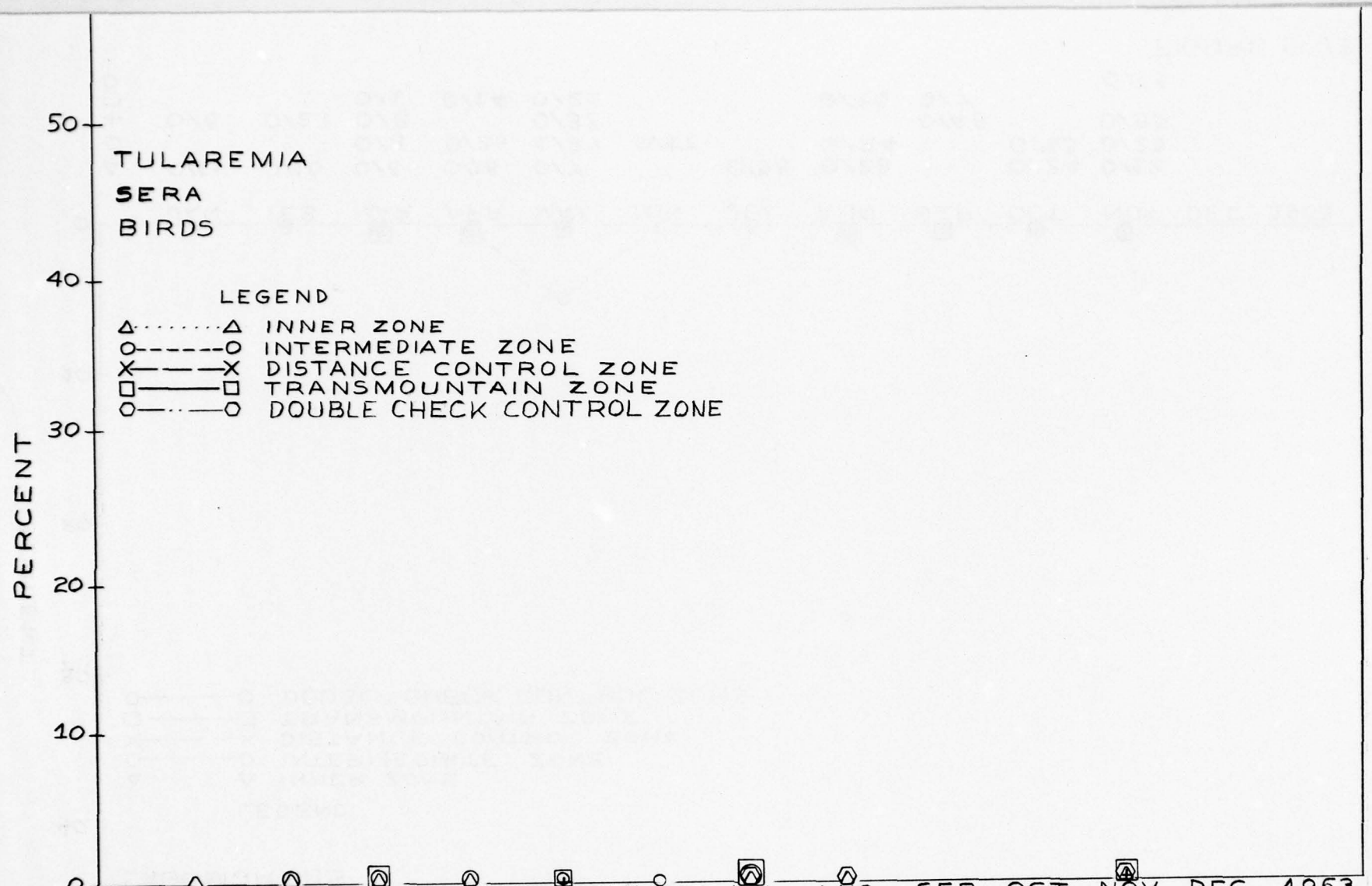
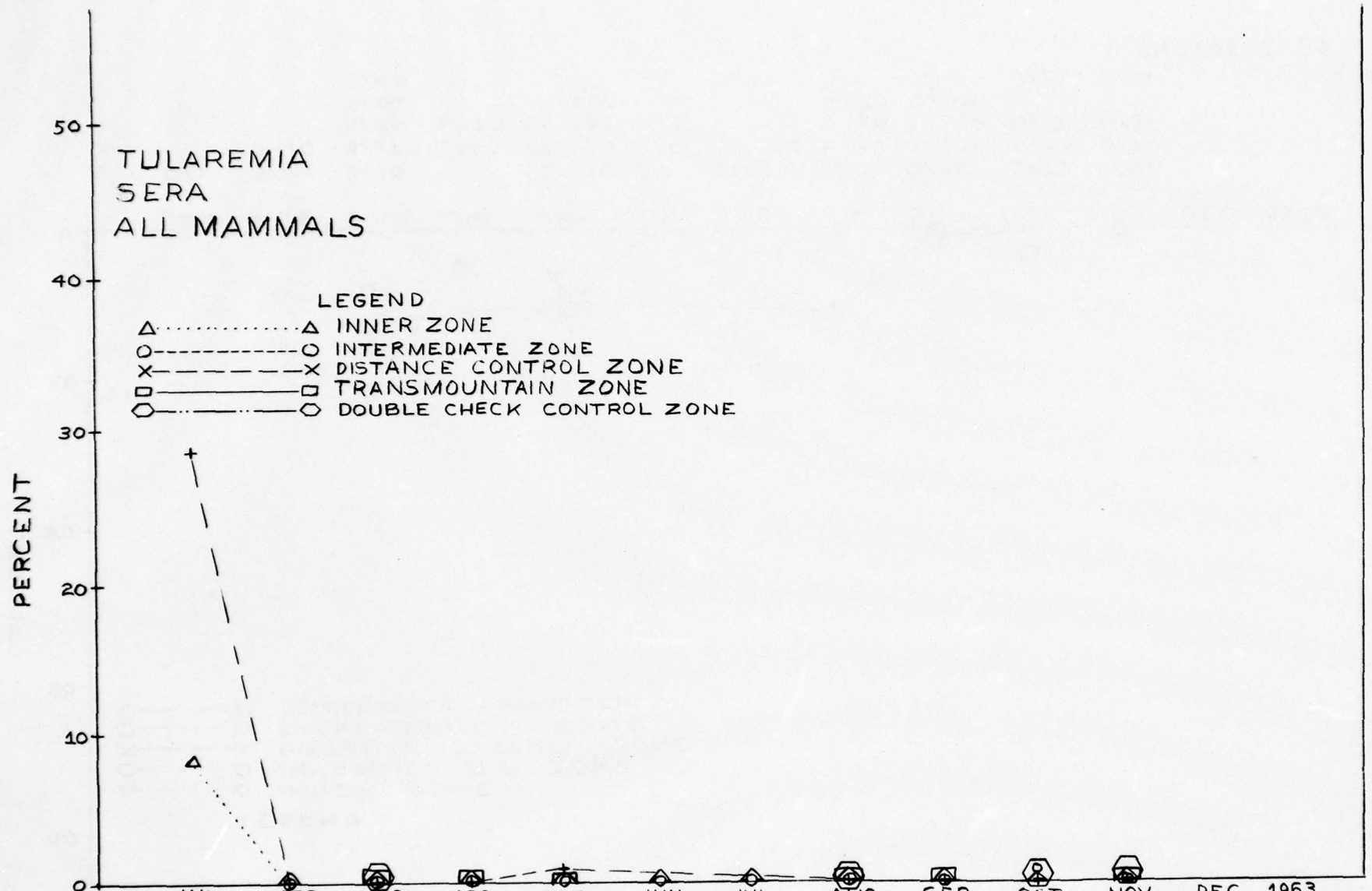

TULAREMIA
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
0/13 0/16 0/6 0/2 0/11 0/66 0/31
0/4 0/1 0/8 0/5 0/35 0/64
0/2 0/13
0/1 0/1 0/9 0/2
0/176 0/7 0/11

FIGURE E-19



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
△	1/12	0/221	0/32	0/18	0/183	0/1	0/339	0/56	0/71	0/96	0/41
○		0/70	0/40	0/63	0/188	0/51	0/118	0/63	0/127	1/109	0/30
+	4/14	0/23	0/87	0/45	2/195			0/30	0/208	0/9	0/71
□			0/65	0/68	0/125			0/91	0/44		0/2
◇			0/26					0/2		0/215	2/40

FIGURE E - 20

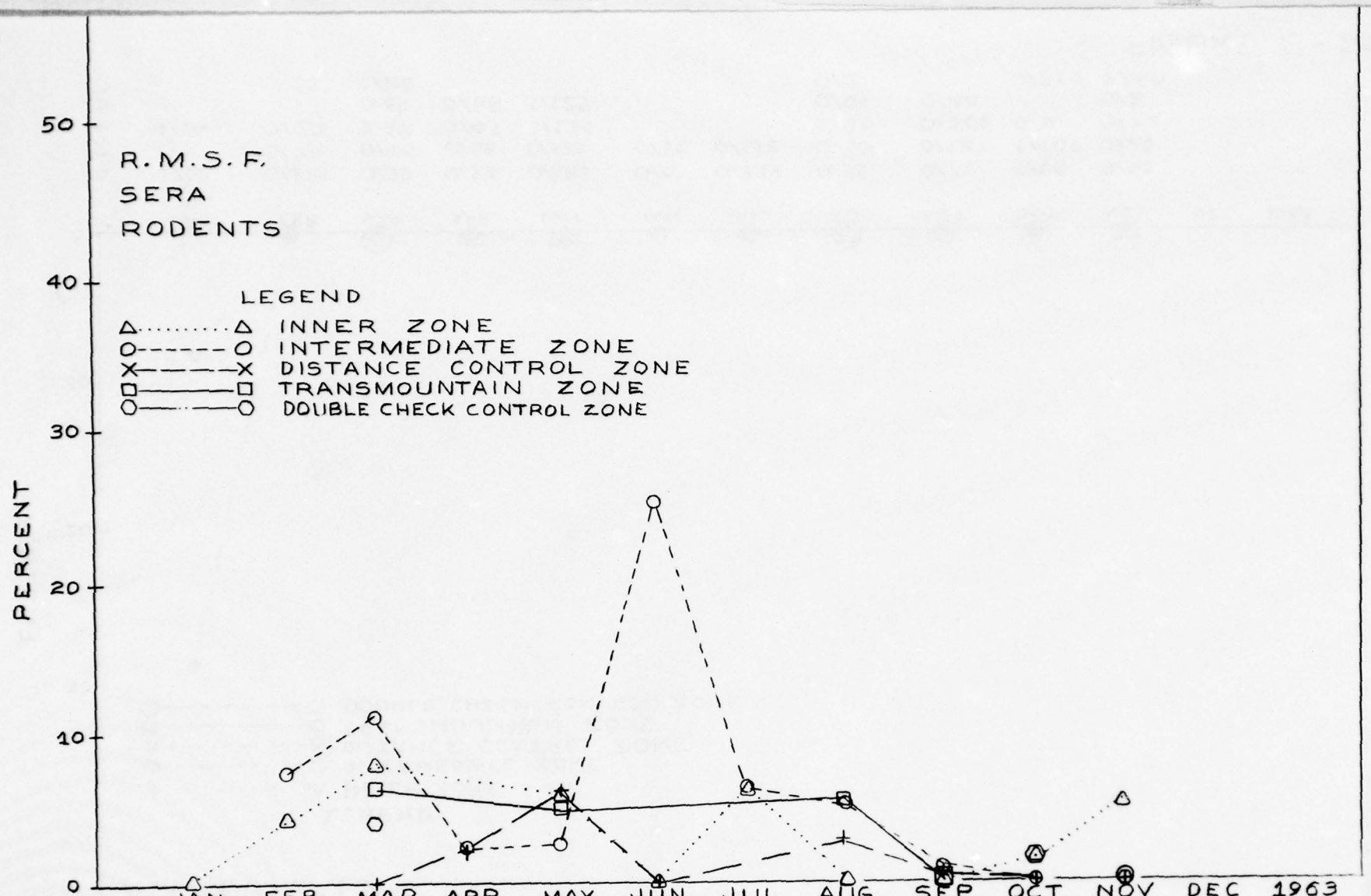

R.M.S.F.
SERA
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/1 9/211 2/26 10/176 0/1 17/281 0/10 0/71 1/72 5/98
○ 5/70 4/37 1/40 3/120 1/4 9/146 2/39 1/114 0/84 0/30
+ 0/79 1/45 10/163 0/3 1/36 1/162 0/9 0/3
□ 4/64 5/104 4/75 0/37
○ 1/26 3/215 0/13

FIGURE E-21

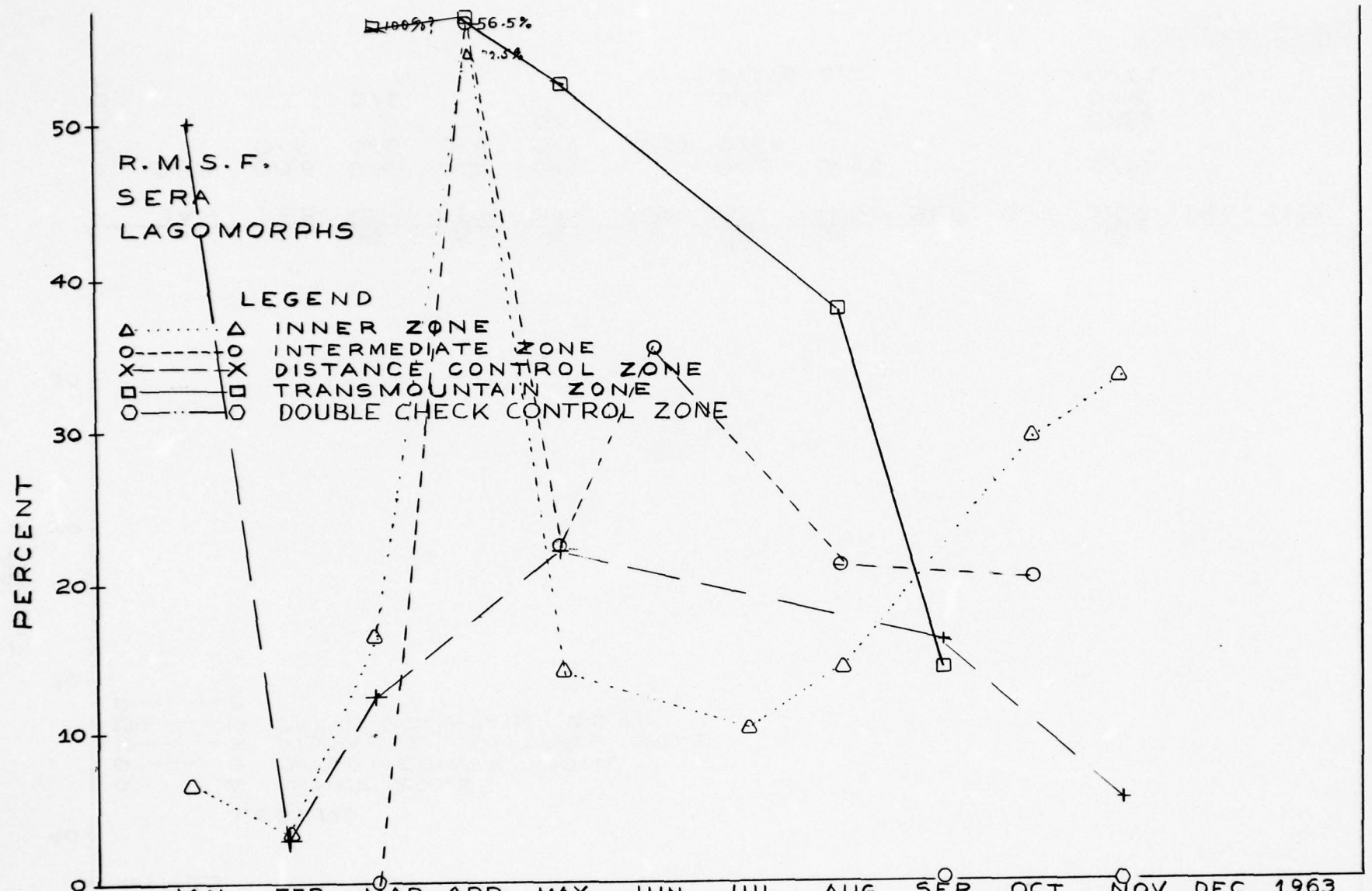

R.M.S.F.
SERA
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
0
10
20
30
40
50
56.5%
72.5%
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 7/11 3/10 1/6 13/18 1/7 6/58 4/28 7/24 4/12
○ 0/3 13/23 6/27 6/17 5/24 0/13 5/25
+ 3/6 7/23 1/8 7/32 7/46 3/55
□ 1/1 8/14 13/21 6/16 1/7
○ 0/16

FIGURE 5-22.

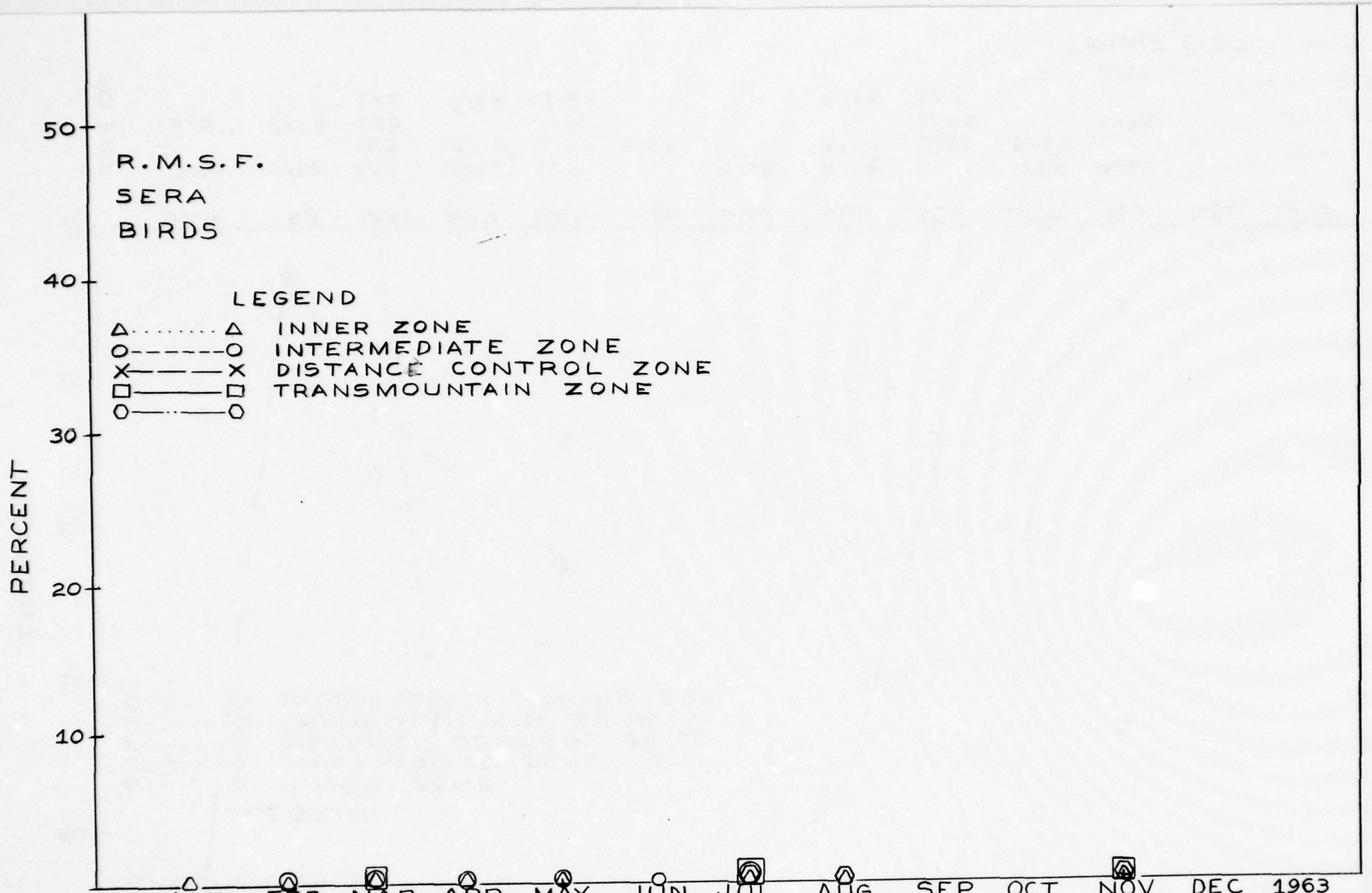
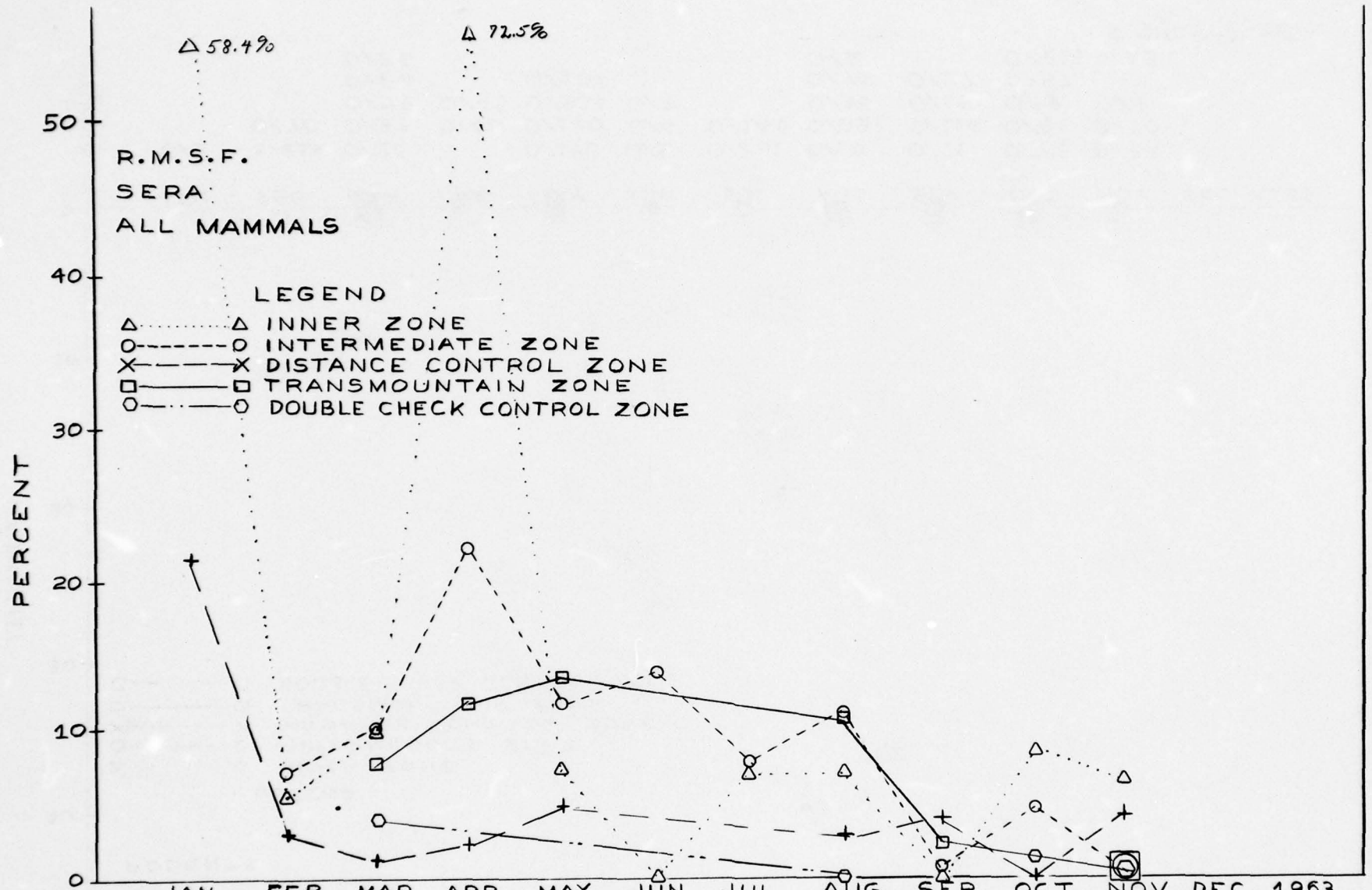

R.M.S.F.
SERA
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
PERCENT
50
40
30
20
10
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
△ 0/13 0/16 0/6 0/2 0/5 0/11 0/66 0/31
O 0/4 0/1 0/8 0/2 0/35 0/64 0/13
+ 0/1 0/2
□ 0/1 0/9 0/11
O 0/176 0/7

FIGURE E-23



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1963
△	7/12	12/221	3/32	13/18	13/183	0/1	23/339	4/56	0/71	8/96	9/141		
O		5/70	4/40	14/63	16/188	7/51	9/118	7/63	1/127	5/109	0/30		
+	3/14	7/23	1/87	1/45	9/195			1/36	8/208	0/9	3/71		
□			5/65	8/68	18/125			10/91	1/44		0/2		
								0/2		3/215	0/40		

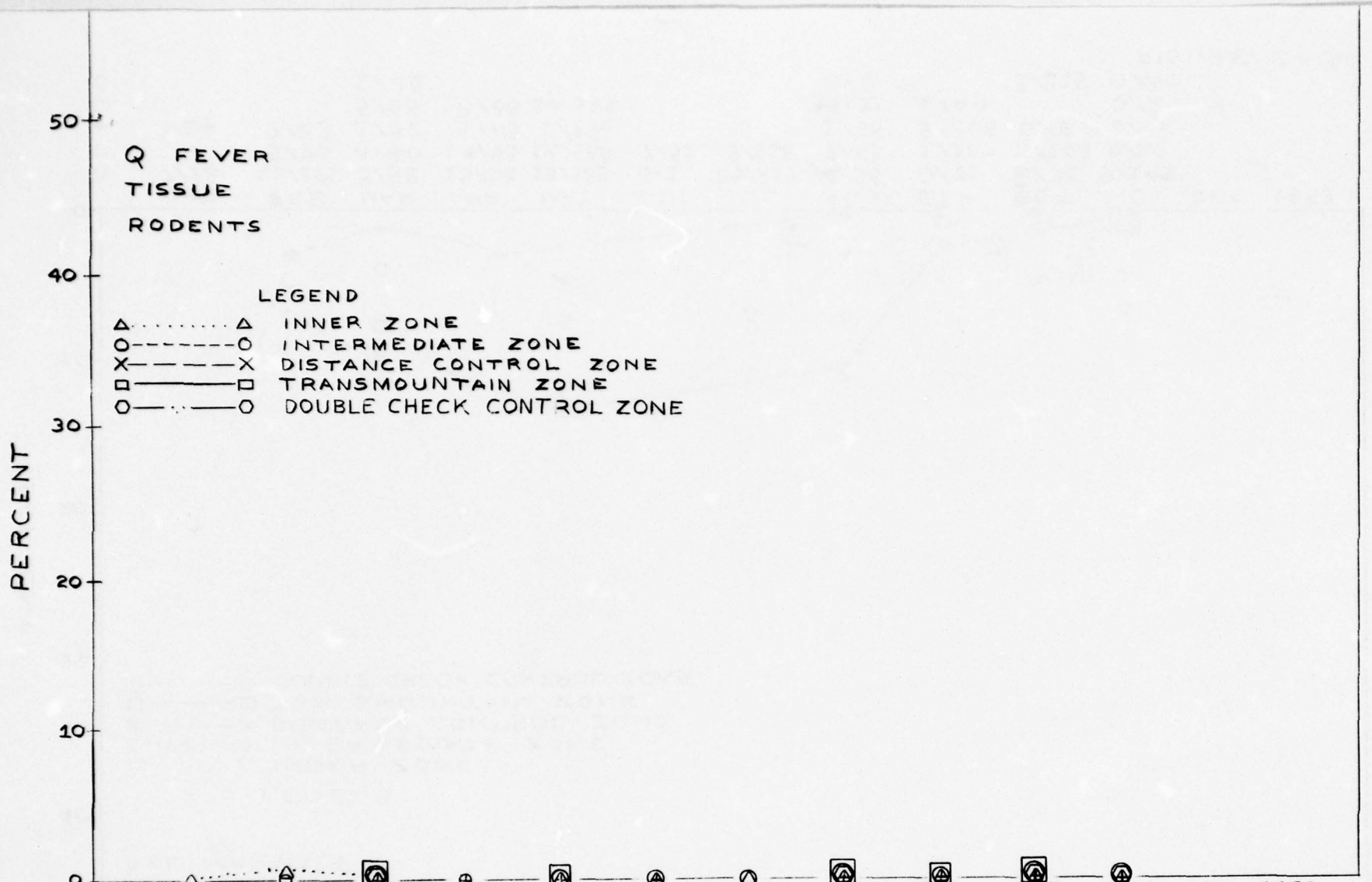

Q FEVER
TISSUE
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/1 1/211 0/26 0/176 0/1 0/281 0/10 0/71 0/72 0/98
○ 0/70 0/37 0/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 0/45 0/163 0/3 0/36 0/162 0/9 0/3
□ 0/64 0/104 0/75 0/37 0/37
○ 0/26 0/2 0/215 0/13

FIGURE E-25

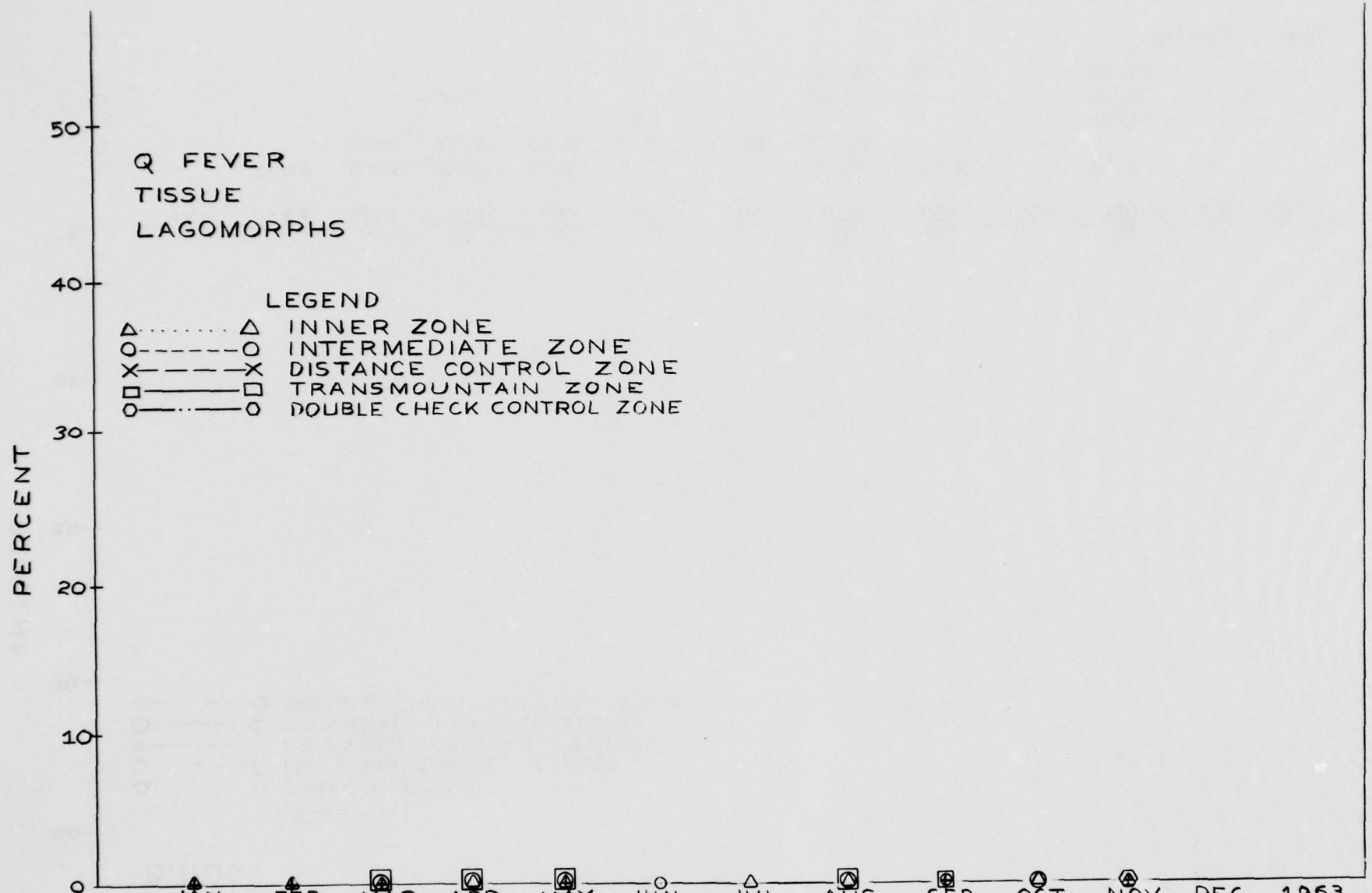

Q FEVER
TISSUE
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/24 0/12
0/3 0/23 0/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 0/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
0 0/16

FIGURE E-26

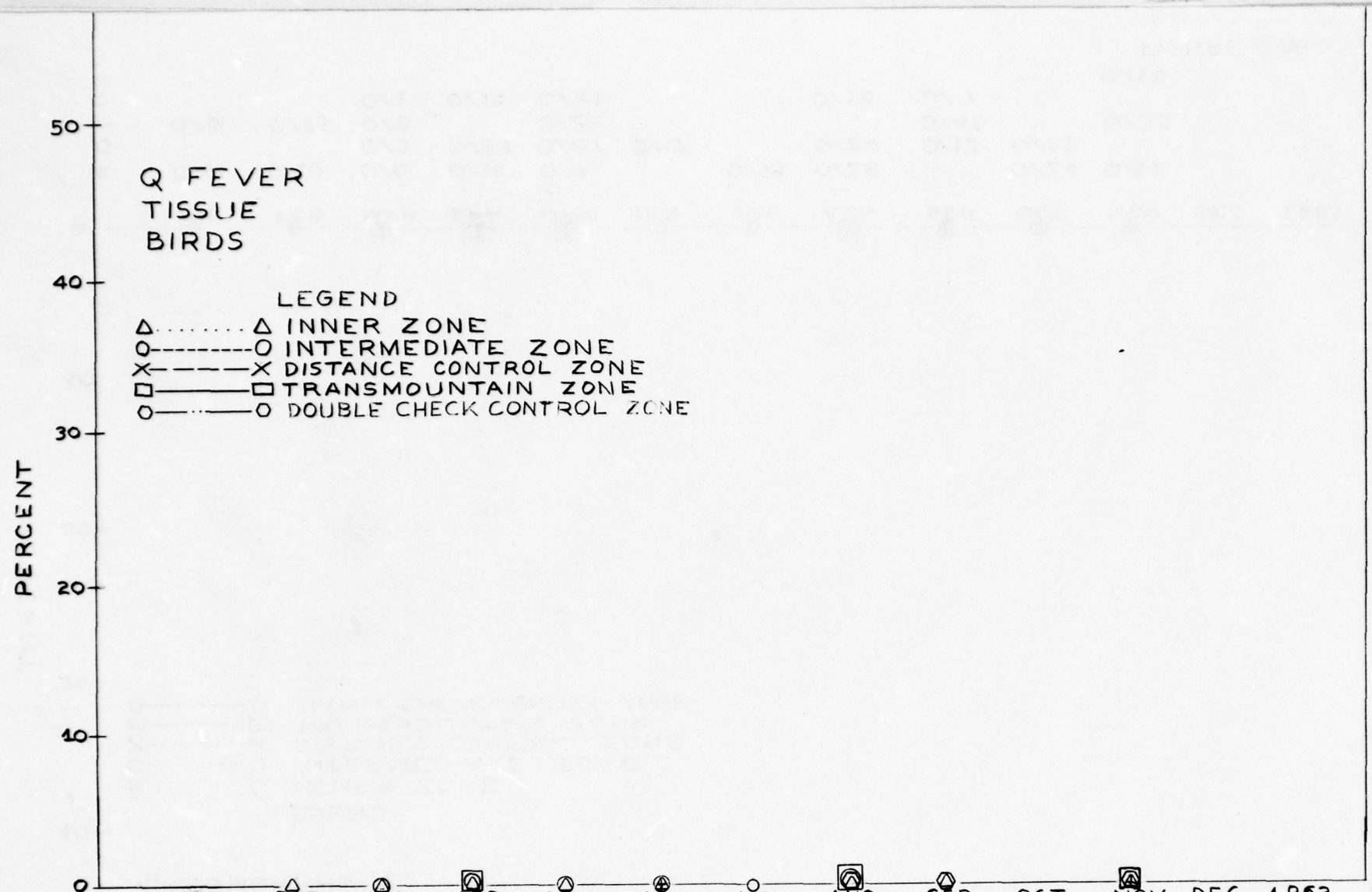
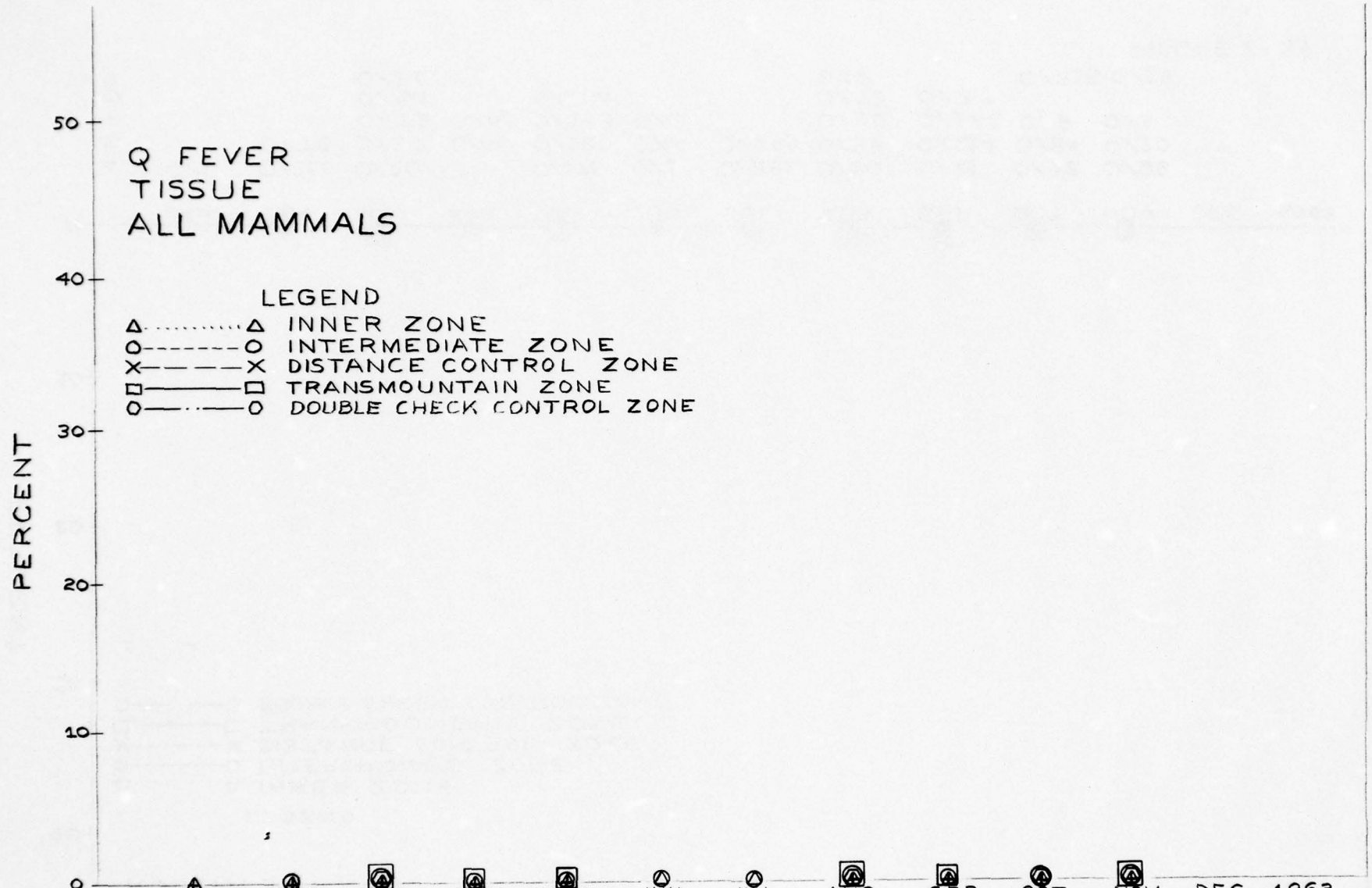

Q FEVER
TISSUE
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/13 0/16 0/6 0/2 0/5 0/11 0/66 0/31
○ 0/4 0/1 0/8 0/2 0/35 0/64 0/13
+ 0/1 0/1 0/9 0/2
□ 0/176 0/7 0/11

FIGURE E-27


Q FEVER
TISSUE
ALL MAMMALS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/12 0/221 0/32 0/18 0/183 0/1 0/339 0/56 0/71 0/96 0/141
○ 0/70 0/40 0/63 0/188 0/51 0/118 0/63 0/127 0/109 0/30
+ 0/14 0/23 0/87 0/45 0/195 0/36 0/208 0/9 0/71
□ 0/65 0/68 0/125 0/91 0/44 0/2
0/26 0/2 0/215 0/140

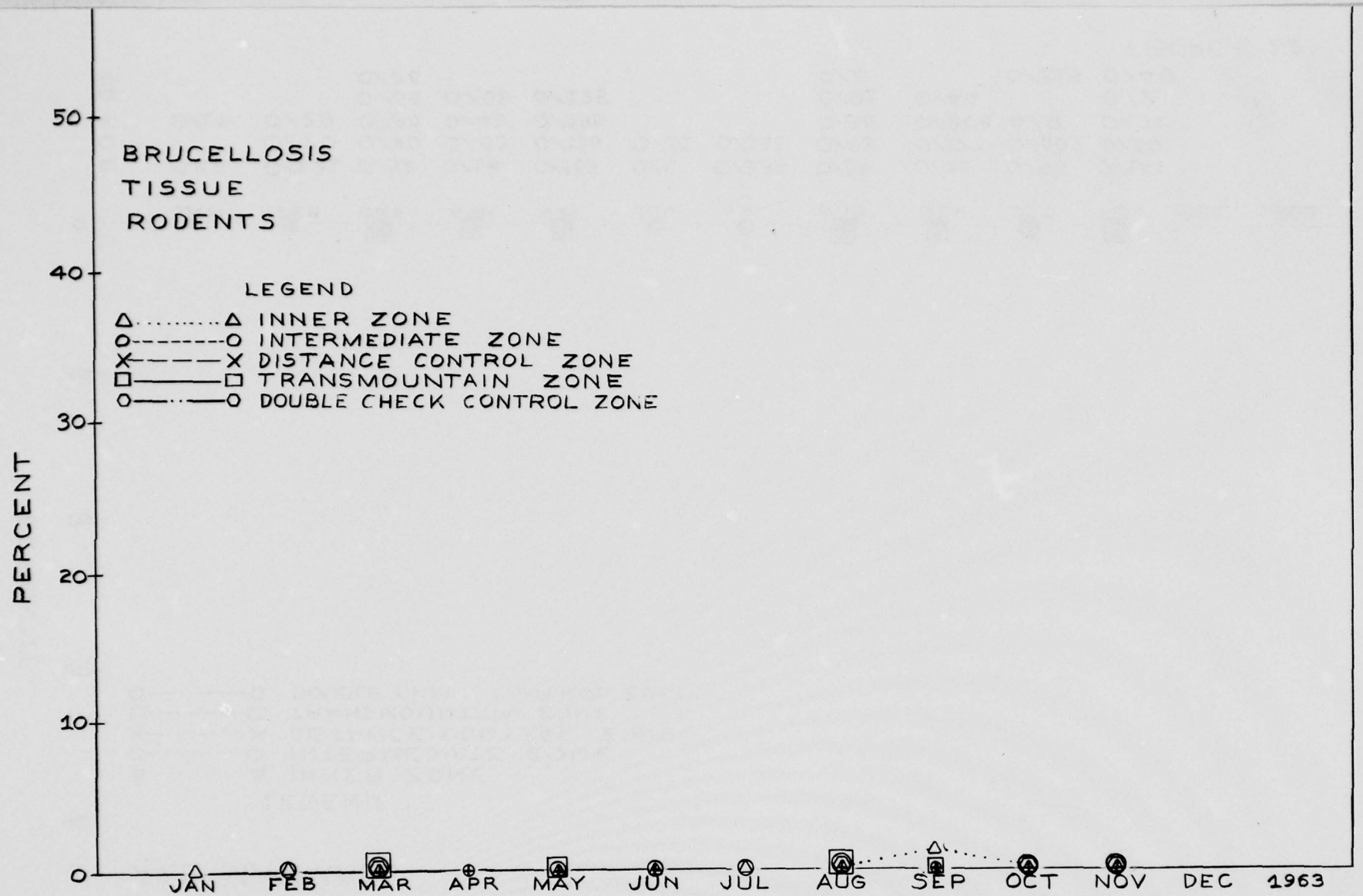

BRUCELLOSIS
TISSUE
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 0/1 0/211 0/26 0/176 0/1 0/281 0/10 1/71 0/72 0/98
O 0/70 0/37 0/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 0/45 0/163 0/3 0/36 0/162 0/9 0/3
□ 0/64 0/104 0/75 0/37
O 0/26 0/2 0/215 0/13

FIGURE E-29

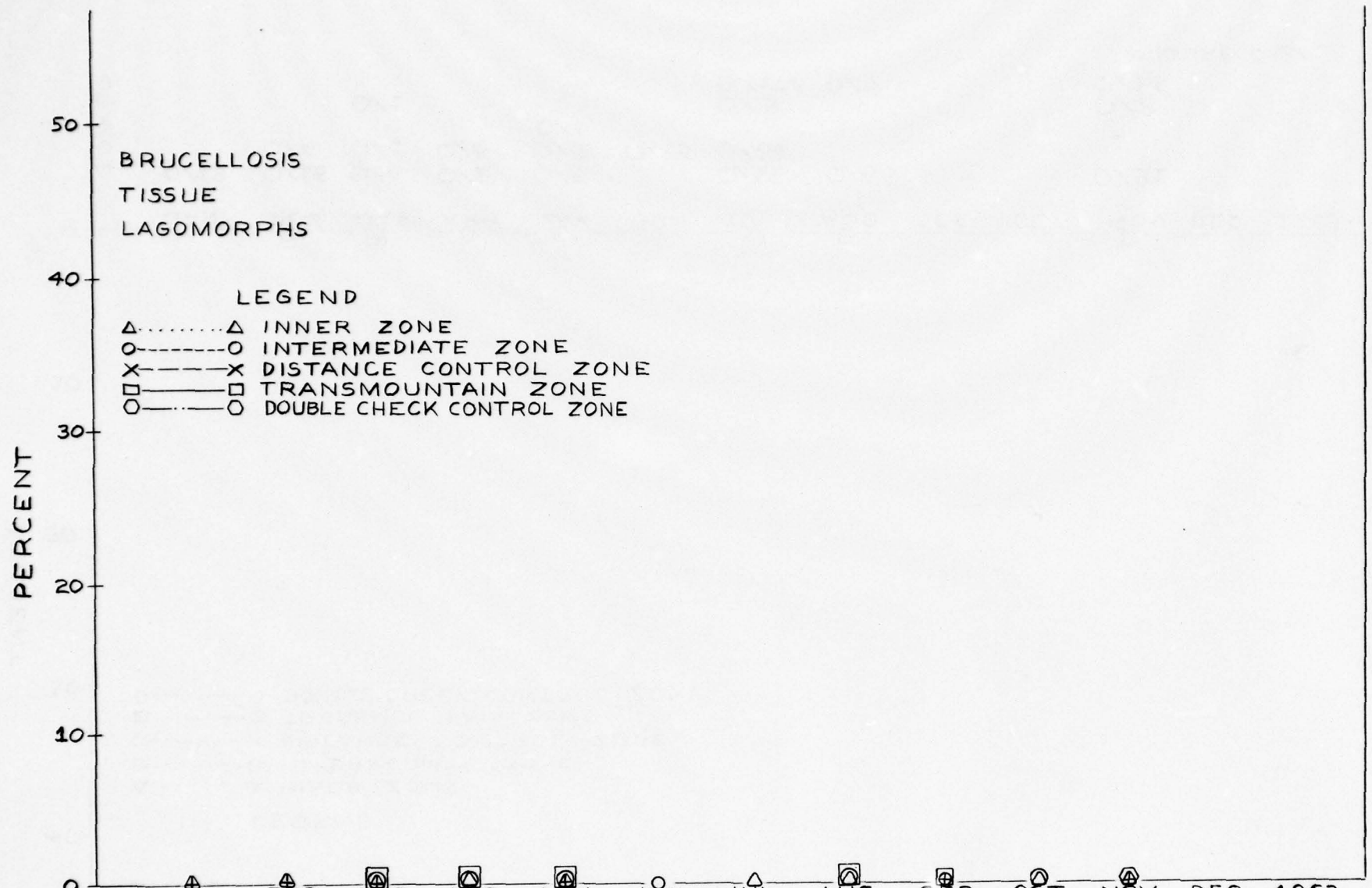

BRUCELLOSIS
TISSUE
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/24 0/2
○ 0/3 0/23 0/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 0/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
◇ 0/16

FIGURE E-30

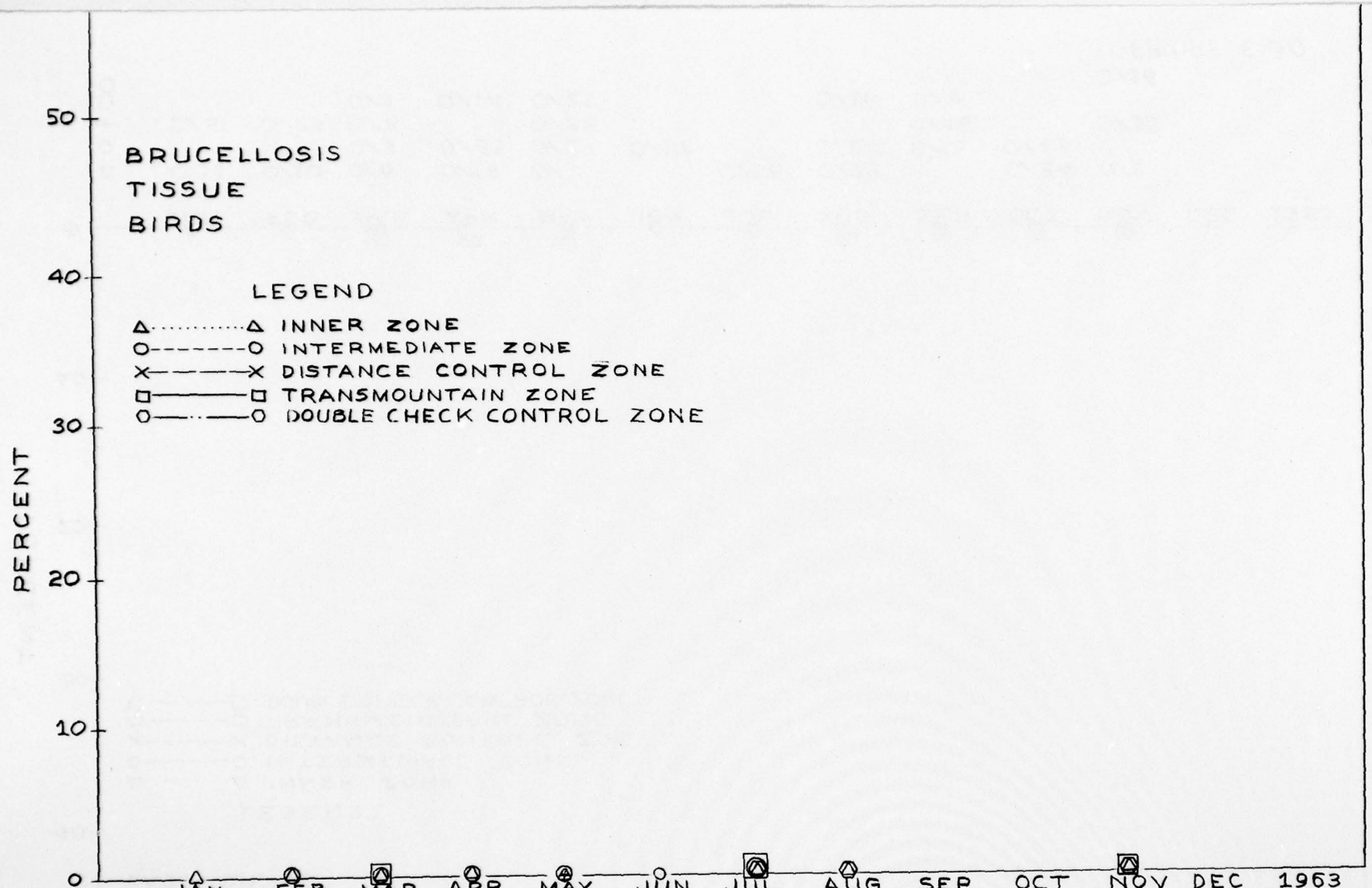

BRUCELLOSIS
TISSUE
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
0/13
0/16
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/35
0/11
0/64
0/9
0/176
0/66
0/7
0/31
0/2
0/11

FIGURE E-31

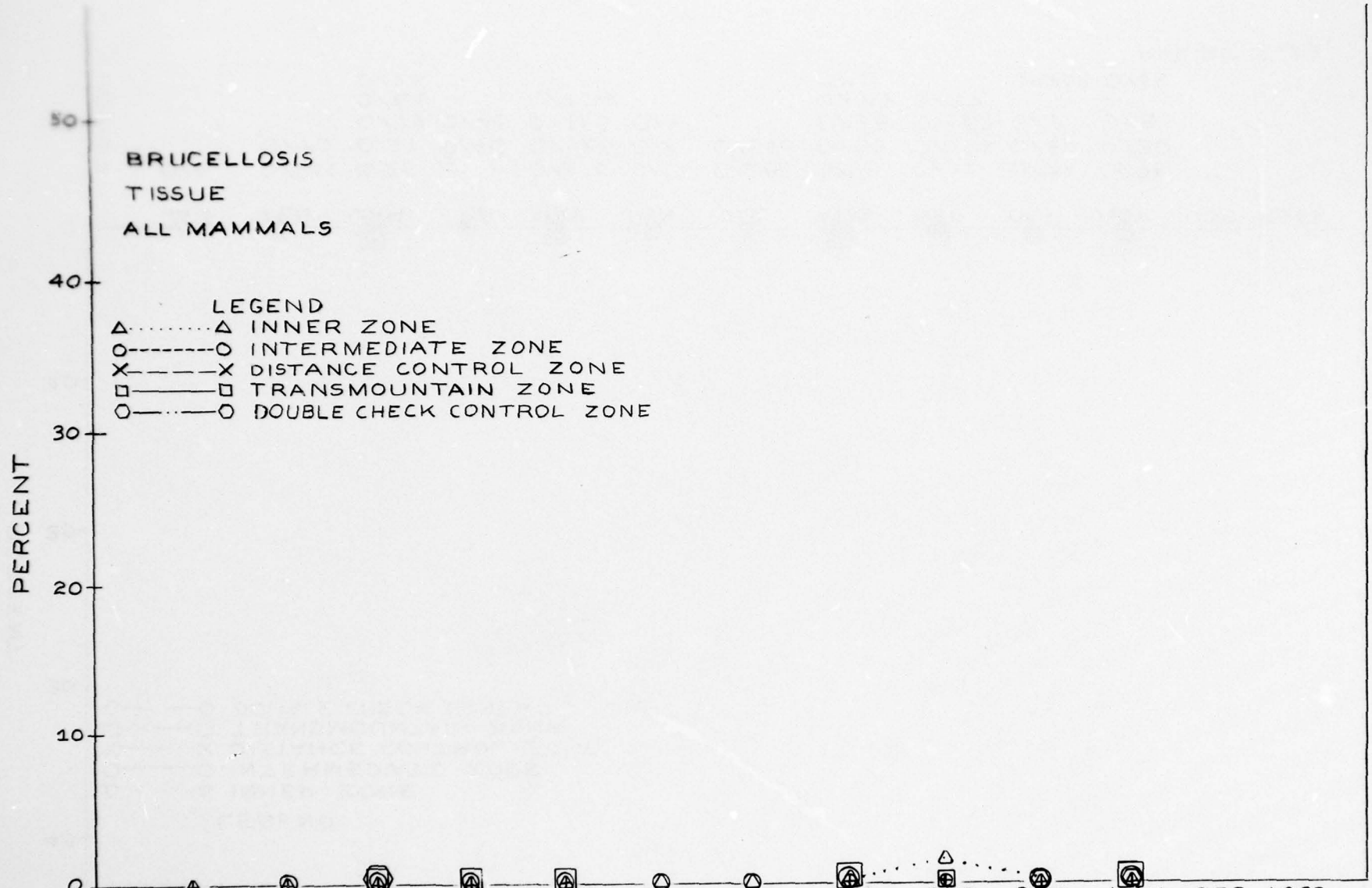

BRUCELLOSIS
TISSUE
ALL MAMMALS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/12 0/221 0/32 0/18 0/183 0/1 0/339 0/56 1/71 0/96 0/141
○ 0/70 0/40 0/63 0/188 0/51 0/118 0/63 0/27 0/109 0/30
+ 0/14 0/23 0/87 0/45 0/195 0/36 0/208 0/9 0/71
□ 0/65 0/68 0/125 0/91 0/44 0/2
◇ 0/26 0/21 0/215 0/40

FIGURE E-32

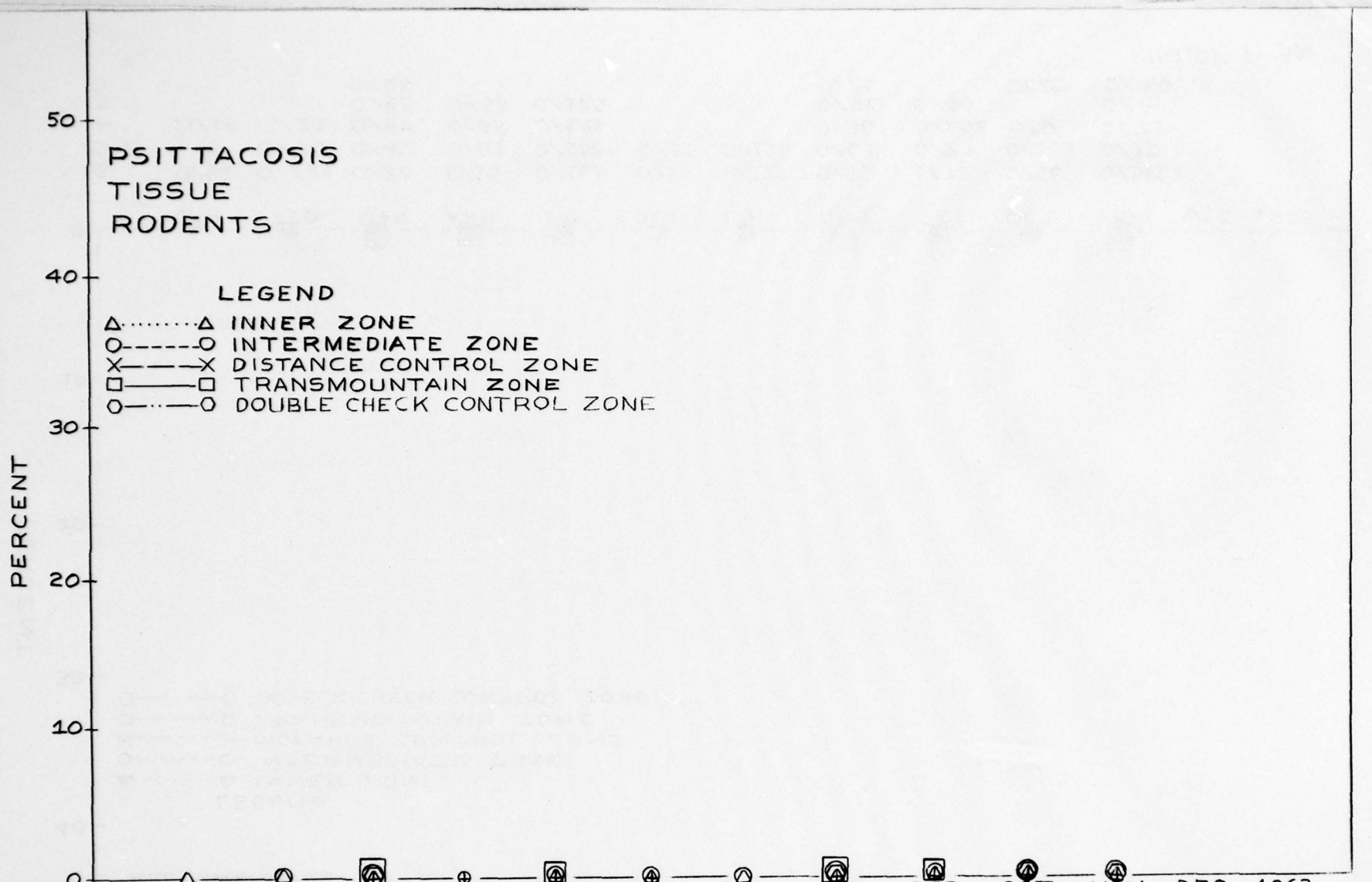

PSITTACOSIS
TISSUE
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/1 0/211 0/26 0/176 0/1 0/281 0/10 0/71 0/72 0/98
O 0/70 0/37 0/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 0/45 0/163 0/3 0/36 0/162 0/9 0/3
□ 0/64 0/104 0/75 0/37
O 0/26 0/2 0/215 0/13

FIGURE E-33

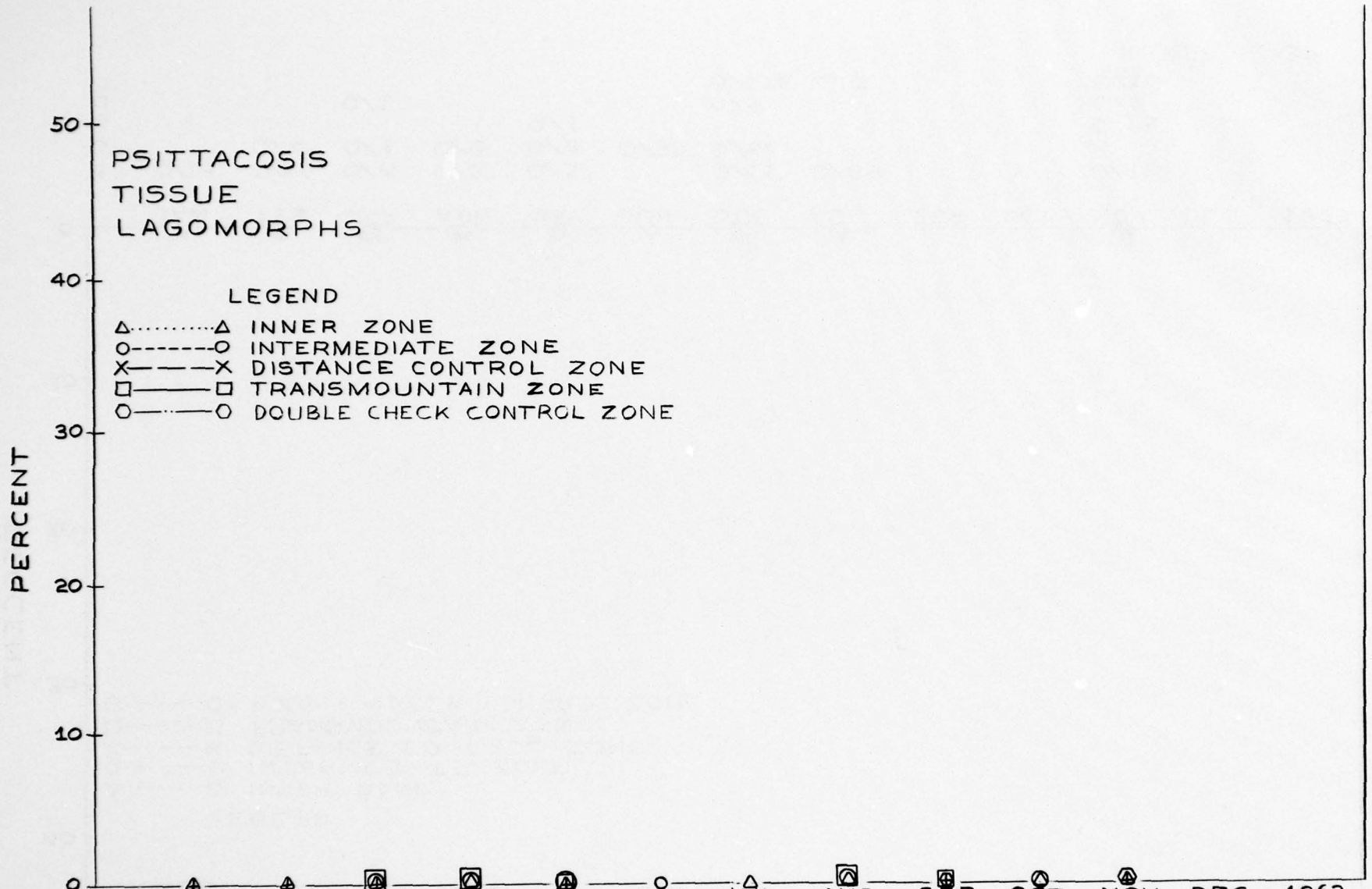

PSITTACOSIS
TISSUE
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/12
O 0/3 0/23 0/27 0/17 0/24 0/13 0/24
+ 0/6 0/23 0/8 0/32 0/46 0/25 0/55
□ 0/1 0/14 0/31 0/16 0/7
O 0/1

FIGURE E-34

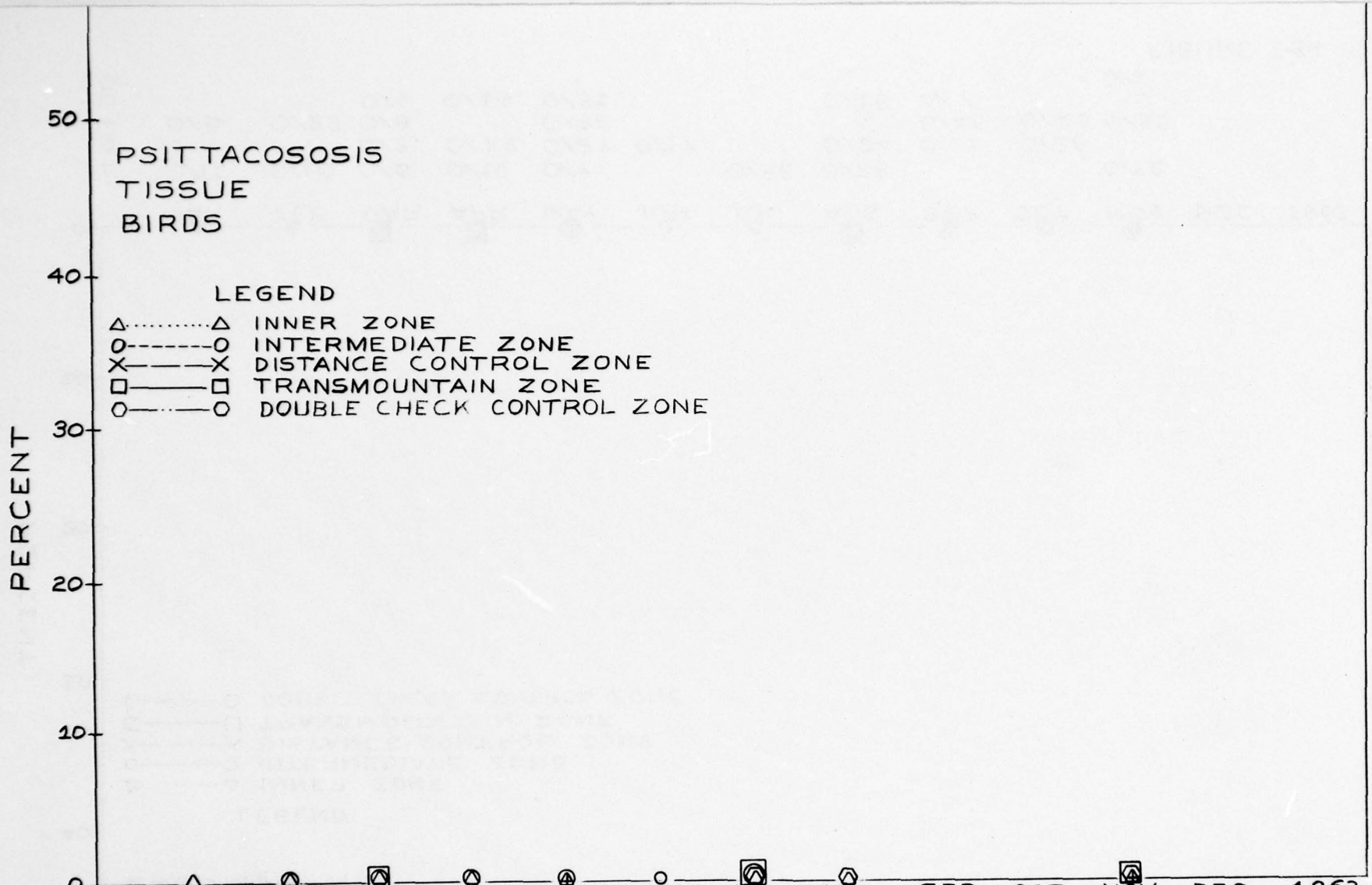
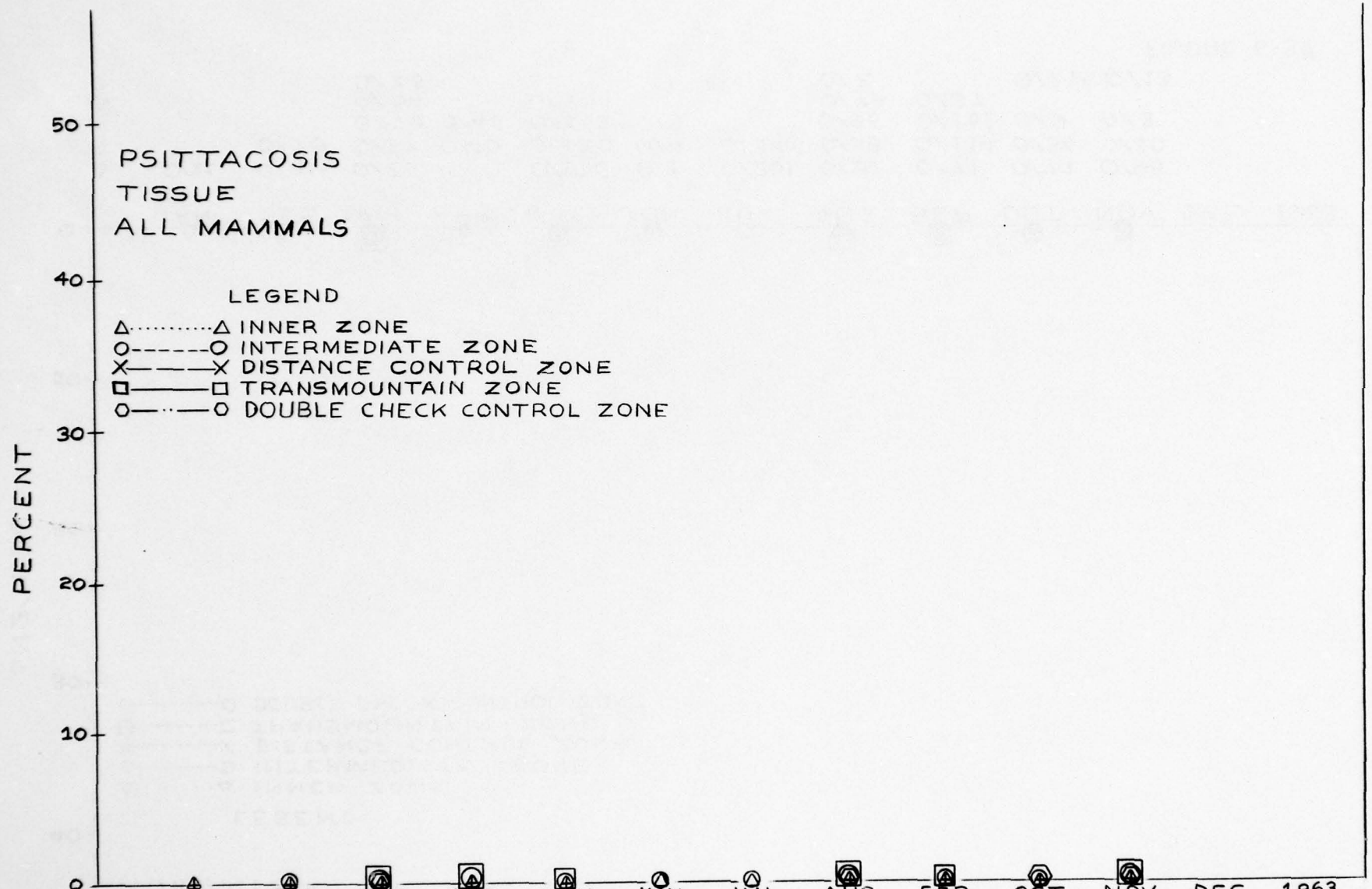

PSITTACOSOSIS
TISSUE
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
△ 0/13 0/16 0/6 0/2 0/5 0/11 0/66 0/31
o 0/4 0/1 0/8 0/2 0/35 0/64 0/13
+ 0/1 0/1 0/2
□ 0/9 0/11
0/176 0/7

FIGURE E-35



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
△	0/12	0/221	0/32	0/18	0/183	0/1	0/339	0/56	0/71	0/96	0/141	
○		0/70	0/40	0/63	0/188	0/51	0/118	0/63	0/127	0/109	0/30	
+	0/14	0/23	0/87	0/45	0/195			0/36	0/208	0/9	0/71	
□			0/65	0/68	0/125			0/91	0/44		0/2	

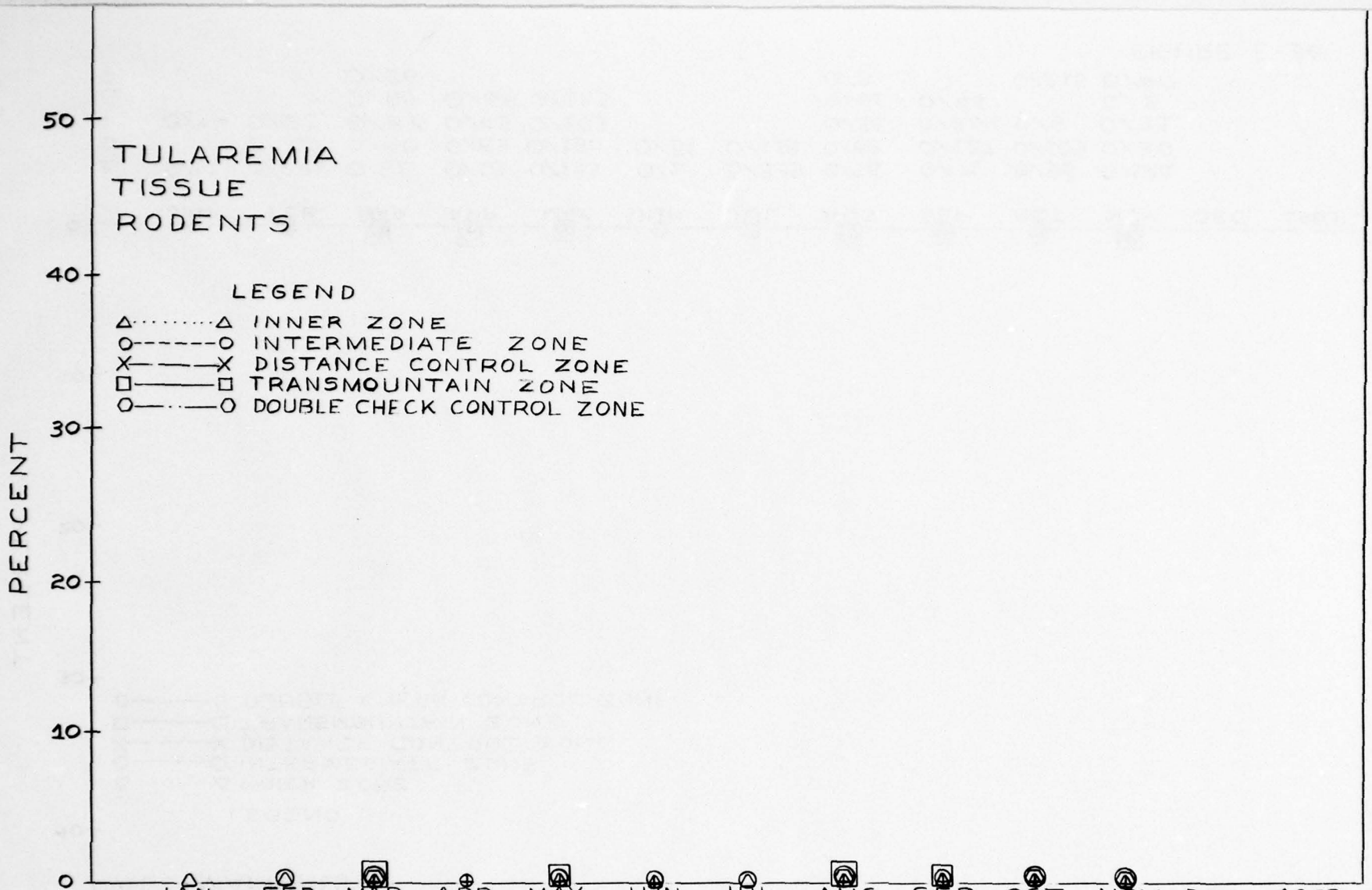

TULAREMIA
TISSUE
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 0/11 0/211 0/26 0/176 0/1 0/281 0/10 0/71 0/72 0/98
O 0/70 0/37 0/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 0/45 0/163 0/3 0/36 0/162 0/9 0/3
□ 0/64 0/104 0/75 0/37
O 0/26 0/2 0/215 0/13

FIGURE E-37

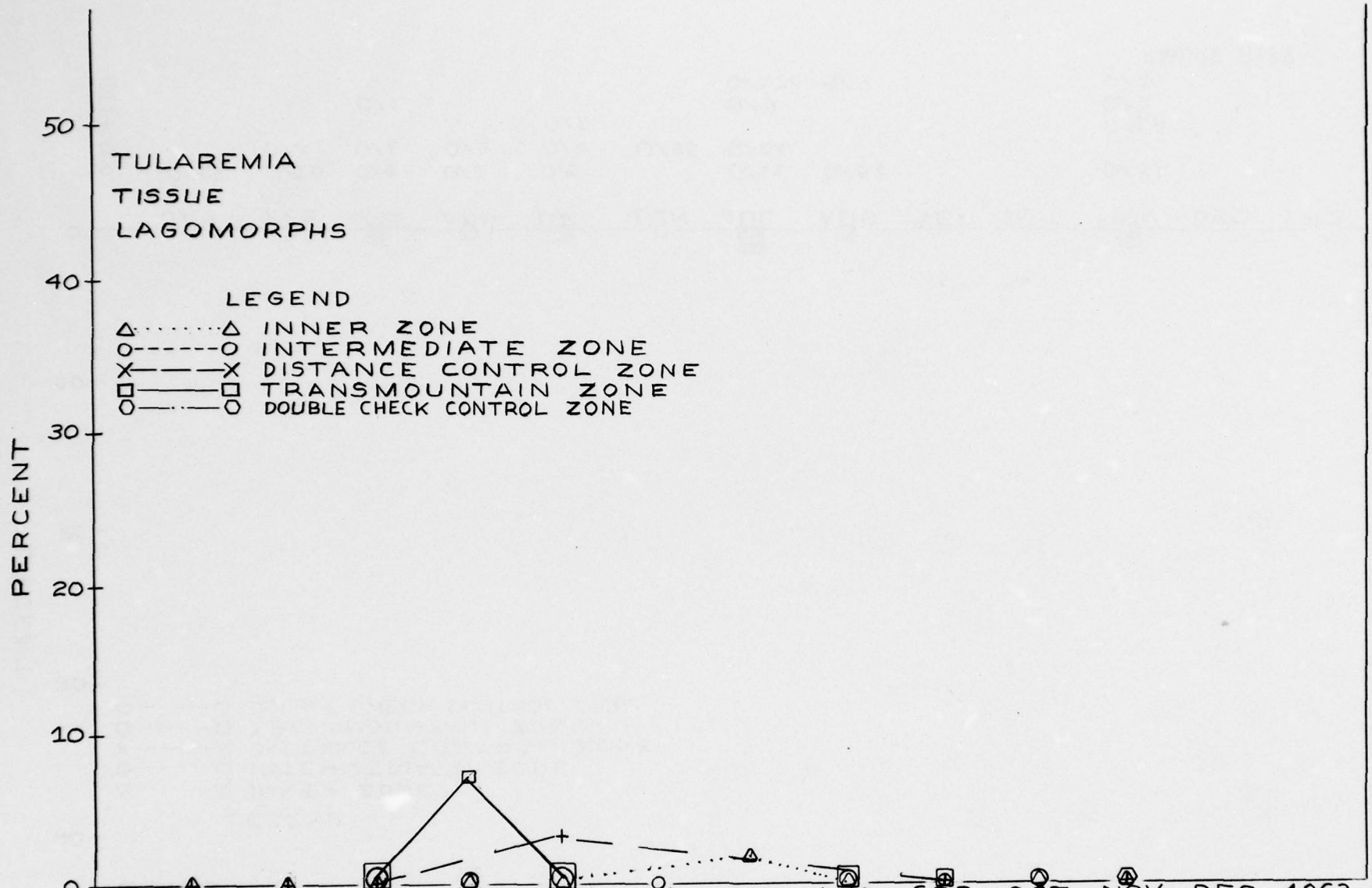

TULAREMIA
TISSUE
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 1/58 0/28 0/24 0/12
○ 0/3 0/23 0/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 1/32 0/46 0/55
□ 0/1 1/14 0/21 0/16 0/7
◇ 0/16

FIGURE E-38

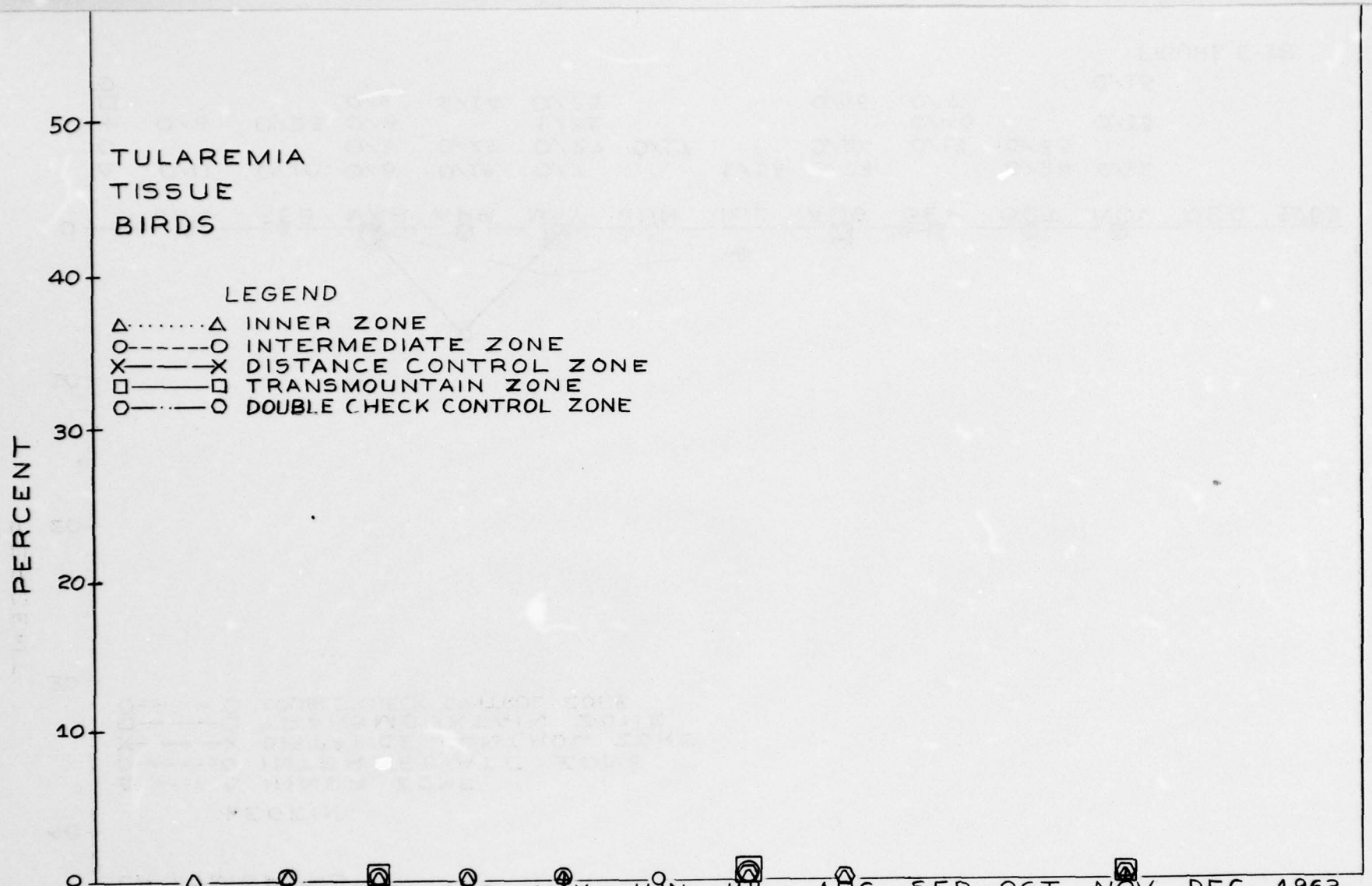

TULAREMIA
TISSUE
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
0/13
0/16
0/4
0/6
0/1
0/1
0/2
0/8
0/5
0/2
0/1
0/35
0/11
0/64
0/9
0/176
0/66
0/7
0/31
0/13
0/2
0/11

FIGURE E-39

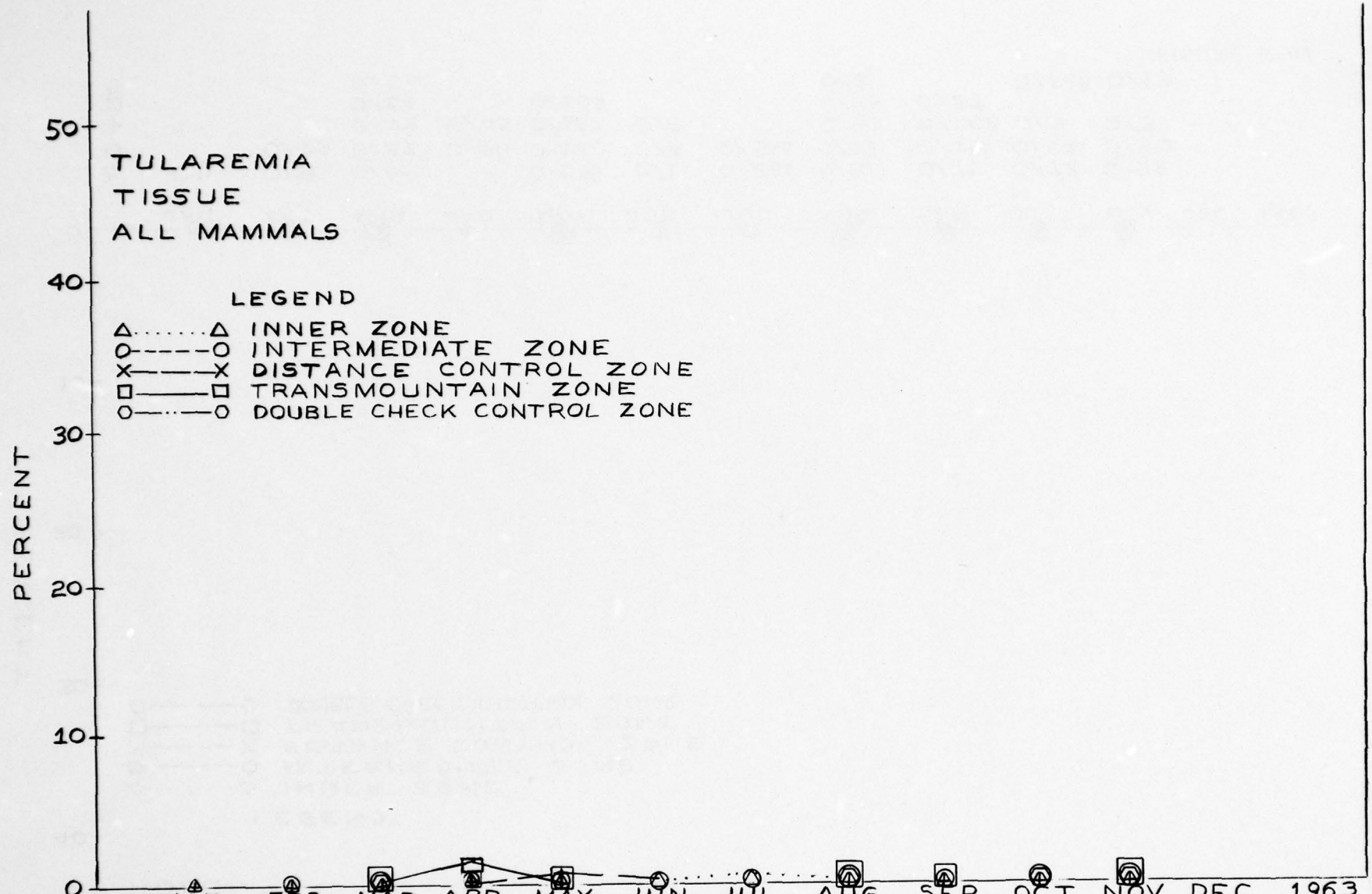

TULAREMIA
TISSUE
ALL MAMMALS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/12 0/221 0/32 0/18 0/183 0/1 1/339 0/56 0/71 0/96 0/141
○ 0/70 0/40 0/63 0/188 0/51 0/118 0/63 0/127 0/109 0/30
+ 0/14 0/23 0/87 0/45 1/195 0/36 0/208 0/9 0/71
□ 0/65 1/68 0/125 0/91 0/44 0/2
◇ 0/26 0/2 0/215 0/40

FIGURE E-40

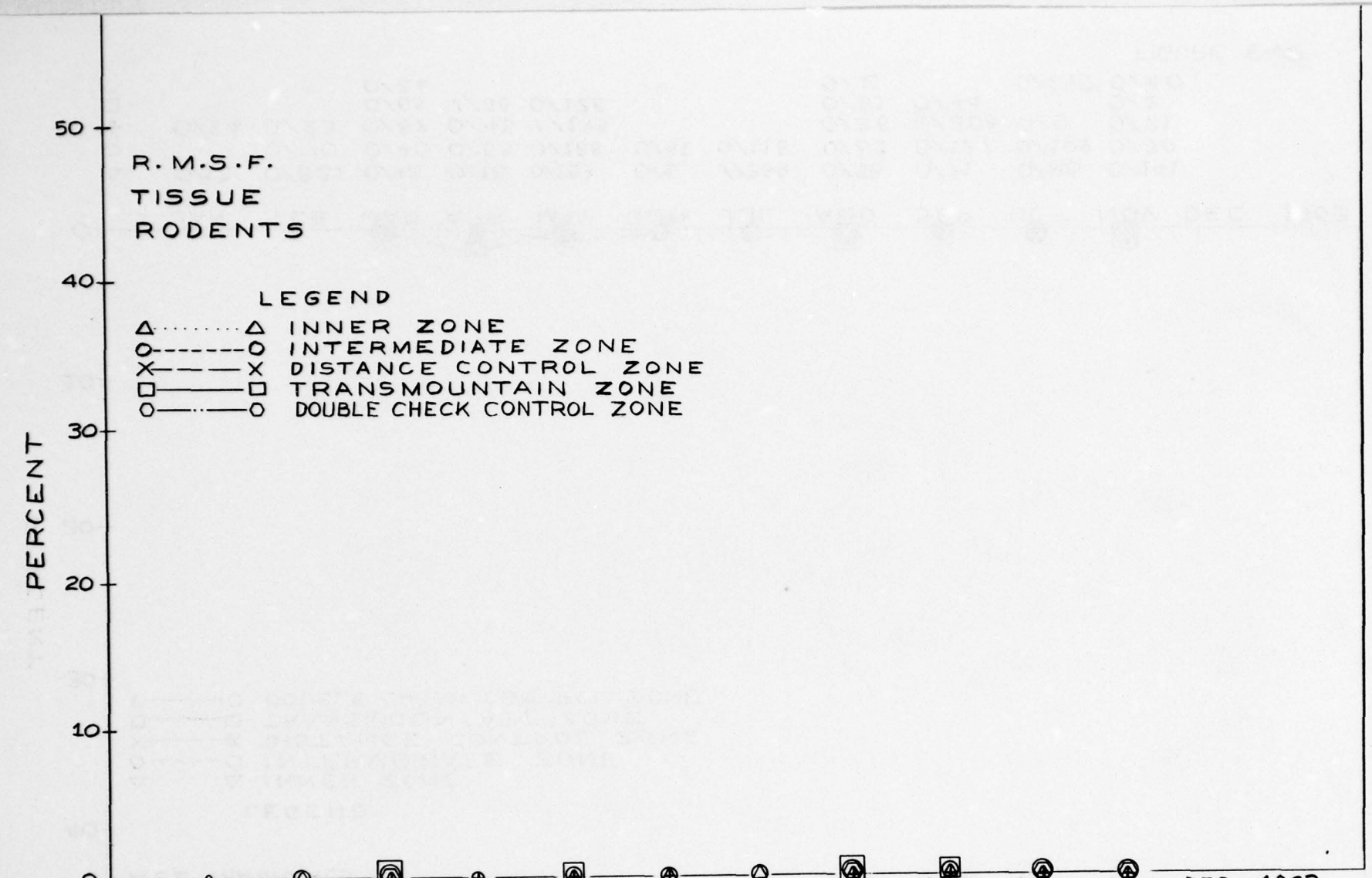

R. M. S. F.
TISSUE
RODENTS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
Δ 0/1 0/211 0/26 0/176 0/1 0/281 0/10 0/71 0/72 0/98
O 0/70 0/37 0/40 0/120 0/4 0/146 0/39 0/114 0/84 0/30
+ 0/79 0/45 0/163 0/3 0/36 0/162 0/9 0/3
□ 0/64 0/104 0/75 0/37
O 0/26 0/2 0/215 0/13

FIGURE E-41

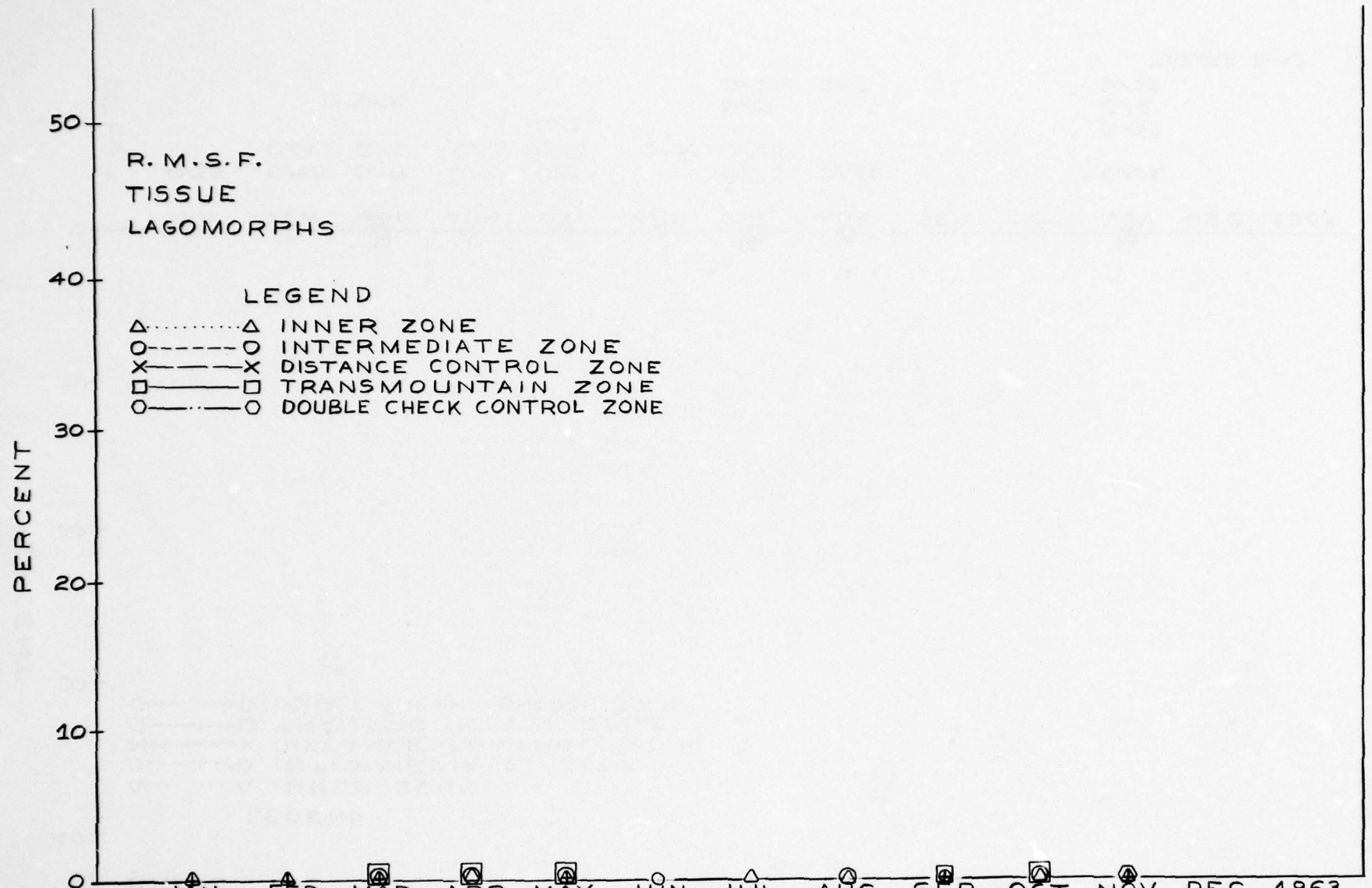

R. M. S. F.
TISSUE
LAGOMORPHS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/11 0/10 0/6 0/18 0/7 0/58 0/28 0/24 0/12
○ 0/3 0/23 0/27 0/17 0/24 0/13 0/25
+ 0/6 0/23 0/8 0/32 0/46 0/55
□ 0/1 0/14 0/21 0/16 0/7
◇ 0/16

FIGURE E-42

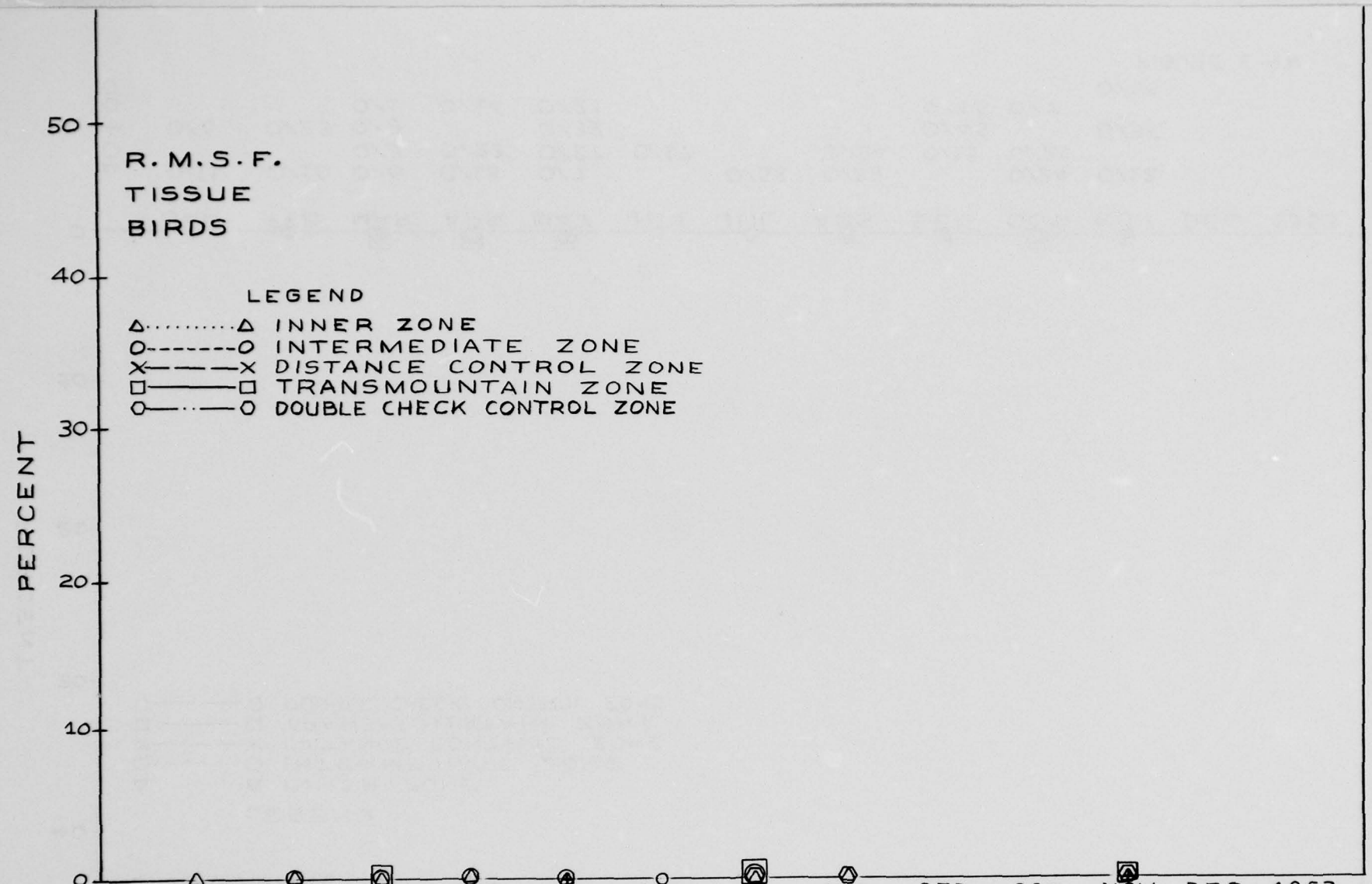

R.M.S.F.
TISSUE
BIRDS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1963
△ 0/13 0/16 0/6 0/2 0/5 0/11 0/66 0/31
O 0/4 0/1 0/8 0/2 0/35 0/64
+ 0/1 0/13
□ 0/1 0/9 0/2
O 0/176 0/7 0/11

FIGURE E-43

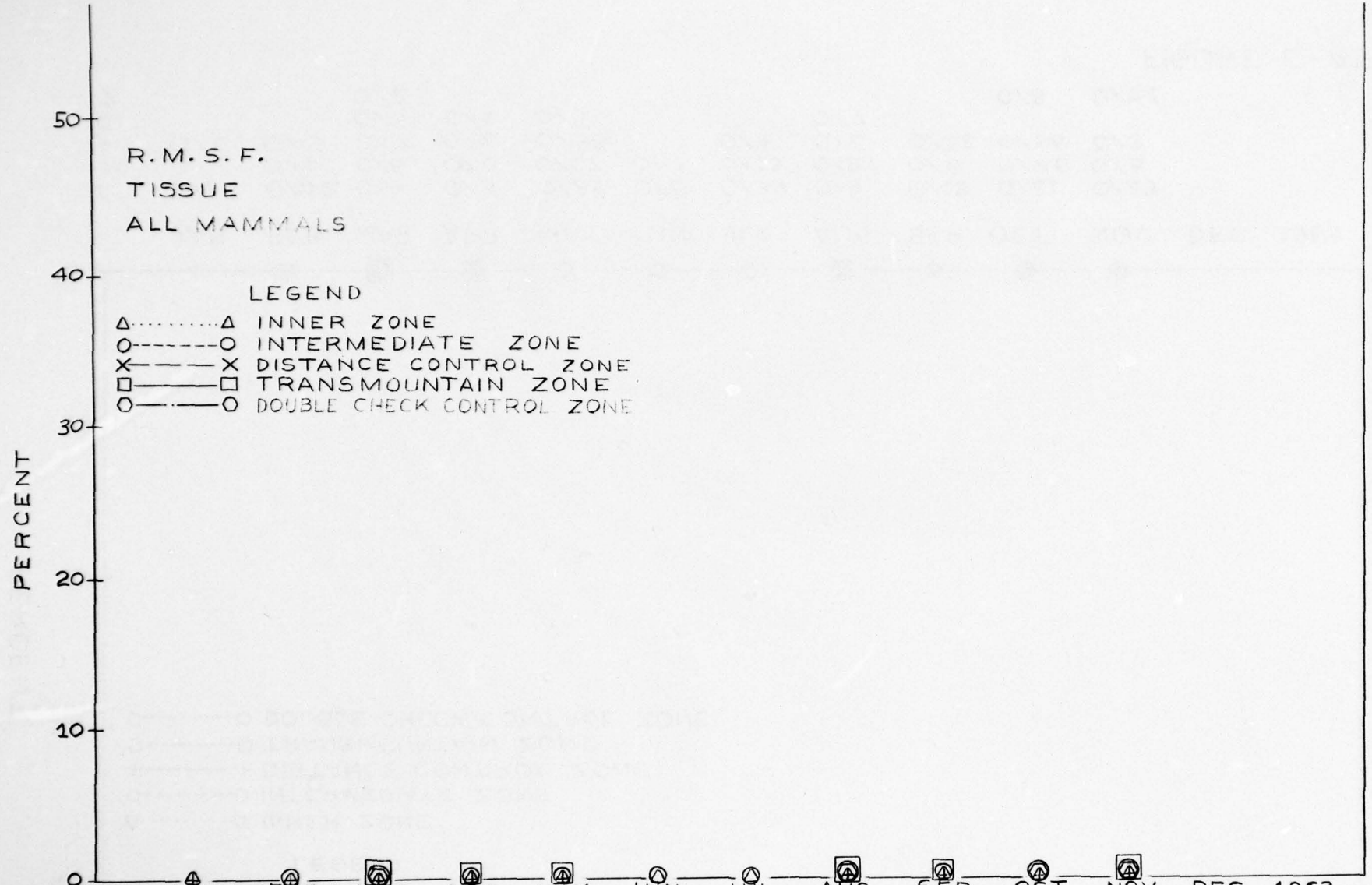

R.M.S.F.
TISSUE
ALL MAMMALS
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
Δ 0/12 0/221 0/32 0/18 0/183 0/1 0/339 0/56 0/71 0/96 0/141
O 0/70 0/40 0/63 0/188 0/51 0/118 0/63 0/127 0/109 0/30
+ 0/14 0/23 0/87 0/45 0/195 0/36 0/208 0/9 0/71
□ 0/65 0/68 0/125 0/91 0/44 0/2
O 0/26 0/2 0/215 0/40

FIGURE E-44

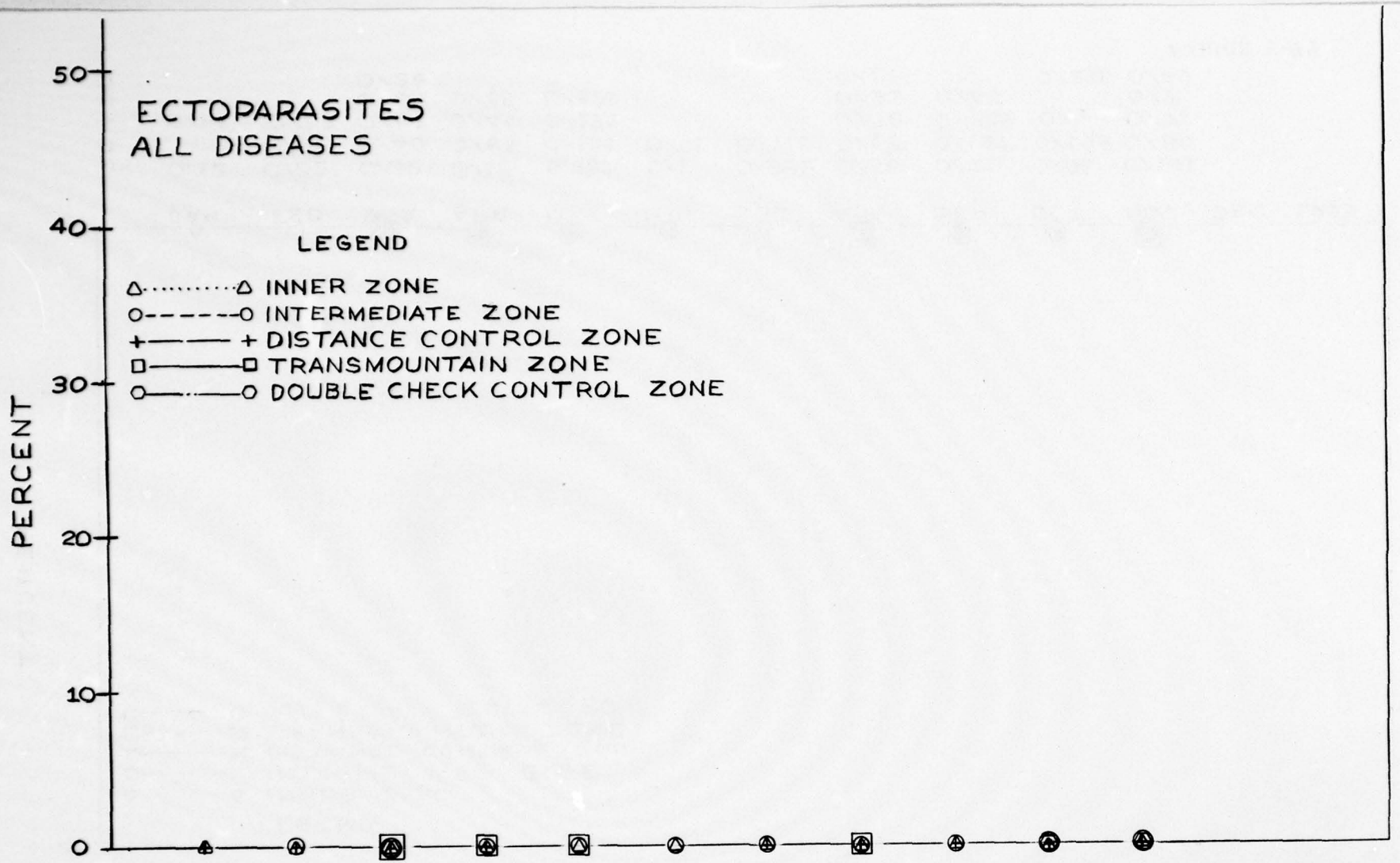

ECTOPARASITES
ALL DISEASES
LEGEND
INNER ZONE
INTERMEDIATE ZONE
DISTANCE CONTROL ZONE
TRANSMOUNTAIN ZONE
DOUBLE CHECK CONTROL ZONE
PERCENT
50
40
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1963
△ 0/1 0/42 0/4 0/3 0/25 0/6 0/37 0/5 0/13 0/21 0/23
○ 0/12 0/5 0/8 0/17 0/7 0/13 0/27 0/6 0/26 0/6
+ 0/1 0/6 0/7 0/6 0/38 0/1 0/6 0/32 0/16 0/3
□ 0/5 0/1 0/16 0/7
○ 0/2 0/8 0/21

FIGURE E-45

AD-A049 134 UTAH UNIV SALT LAKE CITY ECOLOGY AND EPIZOOLOGY RESE--ETC F/G 6/6
A STUDY OF THE ECOLOGY AND EPIZOOLOGY OF THE NATIVE FAUNA OF TH--ETC(U)
JUN 64

UNCLASSIFIED ECOLOGY AND EPIZOOLOGY SE NL

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MAMMALS LISTED IN THIS REPORT

ORDER CHIROPTERA
- Family Vespertilionidae
  - *Myotis volans*
    - Long-legged myotis
  - *Eptesicus fuscus*
    - Big brown bat
  - *Corynorhinus rafinesquii*
    - Long-eared bat
  - *Antrozous pallidus*
    - Pallid bat
- Family Molossidae
  - *Tadarida mexicana*
    - Mexican free-tailed bat

ORDER LAGOMORPHA
- Family Leporidae
  - *Sylvilagus nuttallii*
    - Nuttall cottontail
  - *Sylvilagus audubonii*
    - Desert cottontail
  - *Lepus californicus*
    - Black-tailed jack rabbit
  - *Oryctolagus cuniculus*
    - White rabbit

ORDER RODENTIA
- Family Sciuridae
  - *Eutamias minimus*
    - Least chipmunk
  - *Eutamias dorsalis*
    - Cliff chipmunk
  - *Citellus leucurus*
    - White-tailed antelope squirrel
  - *Citellus townsendii*
    - Townsend ground squirrel
  - *Citellus undulatus*
    - Arctic ground squirrel
  - *Citellus variegatus*
    - Rock squirrel
  - *Citellus beecheyi*
    - California ground squirrel
- Family Geomyidae
  - *Thomomys umbrinus*
    - Southern pocket gopher
  - *Perognathus longimembris*
    - Little pocket mouse
  - *Perognathus parvus*
    - Great Basin pocket mouse
  - *Perognathus formosus*
    - Long-tailed pocket mouse

ORDER RODENTIA (cont'd)
- Family Geomyidae (cont'd)
  - *Microdipodops megacephalus*
    - Dark kangaroo mouse
  - *Dipodomys ordii*
    - Ord kangaroo rat
  - *Dipodomys microps*
    - Chisel-toothed kangaroo rat
- Family Cricetidae
  - *Reithrodontomys megalotis*
    - Western harvest mouse
  - *Peromyscus crinitus*
    - Canyon mouse
  - *Peromyscus maniculatus*
    - Deer mouse
  - *Peromyscus truei*
    - Pinyon mouse
  - *Onychomys leucogaster*
    - Northern grasshopper mouse
  - *Neotoma lepida*
    - Desert wood rat
  - *Neotoma cinerea*
    - Bushy-tailed wood rat
  - *Microtus montanus*
    - Montane vole
  - *Microtus longicaudus*
    - Long-tailed vole
  - *Ondatra zibethicus*
    - Muskrat
  - *Cricetus auratus*
    - Golden hamster
- Family Zapodidae
  - *Zapus princeps*
    - Western jumping mouse
- Family Muridae
  - *Apodemus agrarius*
    - Wood mouse
  - *Rattus rattus*
    - Black rat
  - *Rattus norvegicus*
    - Brown rat
  - *Rattus exulans*
    - Polynesian rat
  - *Mus musculus*
    - House mouse
    - Albino laboratory mouse
- Family Erethizontidae
  - *Erethizon dorsatum*
    - Porcupine

LIST OF MAMMALS (continued)

ORDER CARNIVORA
Family Canidae
Vulpes macrotis
Kit fox
Canis latrans
Coyote
Canis familiaris
Domestic dog

Family Procyonidae
Bassariscus astutus
Ring-tailed cat

Family Mustelidae
Mustela frenata
Long-tailed weasel
Taxidea taxus
Badger
Spilogale putorius
Spotted skunk

Family Felidae
Lynx rufus
Bobcat
Felis catus
House cat
Felis concolor
Mountain lion

ORDER ARTIODACTYLA
Family Cervidae
Odocoileus hemionus
Mule deer

Family Antilocapridae
Antilocapra americana
Prong-horned antelope

Family Bovidae
Bos taurus
Domestic cow

Ovis aries
Domestic sheep

ORDER PERISSODACTYLA
Family Equidae
Equus caballus
Domestic horse

BIRDS LISTED IN THIS REPORT

Pelecaniformes
- *Pelecanus erythrorhynchos*
  - White pelican

Anseriformes
- *Anas platyrhynchos*
  - Common mallard
- *Anas acuta*
  - Pintail
- *Spatula clypeata*
  - Shoveller
- *Anas carolinensis*
  - Green-wing teal
- *Aythya americana*
  - Redhead
- *Anas cyanoptera*
  - Cinnamon teal
- *Oxyura jamaicensis*
  - Ruddy duck

Falconiformes
- *Buteo jamaicensis*
  - Western red-tailed hawk
- *Buteo regalis*
  - Ferruginous red-legged hawk
- *Circus cyaneus*
  - Marsh hawk
- *Falco mexicanus*
  - Prairie falcon
- *Accipiter striatus velox*
  - Sharp-shinned hawk
- *Falco sparverius*
  - Sparrow hawk

Galliformes
- *Alectoris graeca*
  - Chuckar partridge
- *Phasianus colchicus*
  - Ring-necked pheasant

Gruiformes
- *Fulica americana*
  - American coot

Charadriiformes
- *Charadrius alexandrinus*
  - Western snowy plover
- *Charadrius vociferus*
  - Killdeer
- *Numenius americanus*
  - Long-billed curlew
- *Catoptrophorus semipalmatus*
  - Western willet
- *Totanus flavipes*
  - Lesser yellowlegs
- *Erolia bairdii*
  - Baird sandpiper
- *Erolia minutilla*
  - Least sandpiper
- *Ereuntes mauri*
  - Western sandpiper
- *Limosa fedoa*
  - Marbled godwit
- *Recurvirostra americana*
  - Avocet
- *Himantopus mexicanus*
  - Black-necked stilt
- *Steganopus tricolor*
  - Wilson phalarope
- *Larus californicus*
  - California gull
- *Larus philadelphia*
  - Bonaparte gull
- *Sterna forsteri*
  - Forster tern

Columbiformes
- *Columba livia*
  - Domestic pigeon
- *Zenaidura macroura*
  - Western mourning dove

Strigiformes
- *Bubo virginianus*
  - Montana horned owl

Caprimulgiformes
- *Chordeiles minor hesperis*

Piciformes
- *Colaptes cafer collaris*
  - Red-shafted flicker

LIST OF BIRDS (continued)

Passeriformes

- *Tyrannus verticalis*
  Western kingbird
- *Sayornis saya*
  Say's phoebe
- *Eremophila alpestris*
  Horned lark
- *Tachycineta thalassina*
  Violet green swallow
- *Stelgidopteryx ruficollis*
  Rough-winged swallow
- *Aphelocoma coerulescens*
  Scrub jay
- *Pica pica*
  Black-billed magpie
- *Corvus corax*
  Raven
- *Parus gambeli*
  Mountain chickadee
- *Parus inornata*
  Plain titmouse
- *Troglodytes aedon*
  House wren
- *Salpinctes obsoletus*
  Rock wren
- *Mimus polyglottos*
  Mockingbird
- *Oreoscoptes montanus*
  Sage thrasher
- *Turdus migratorius*
  Robin
- *Sialia curricoides*
  Mountain bluebird
- *Myadestes townsendii*
  Townsend's solitaire
- *Bombycilla cedorum*
  Cedar waxwing
- *Lanius ludovicianus*
  Loggerhead shrike
- *Sturnus vulgaris*
  Starling
- *Dendroica coerulescens*
  Black-throated blue warbler
- *Dendroica nigrescens*
  Black-throated gray warbler
- *Opornis tolmiei*
  MacGillivray warbler

Passeriformes (cont'd)

- *Sturnella neglecta*
  Western meadowlark
- *Xanthocephalus xanthocephalus*
  Yellowheaded blackbird
- *Agelaius phoeniceus*
  Redwinged blackbird
- *Euphagus cyanocephalus*
  Brewer blackbird
- *Molothrus ater*
  Brown-headed cowbird
- *Hesperiphona vespertina*
  Evening grosbeak
- *Carpodacus mexicana*
  House finch
- *Spinus tristis*
  Lesser goldfinch
- *Chlorura chlorura*
  Green-tailed towhee
- *Pipilo erythrophthalmus*
  Rufous-sided towhee
- *Passerculus sandwichensis*
  Savannah sparrow
- *Pooecetes gramineus*
  Vesper sparrow
- *Chondestes grammacus*
  Lark sparrow
- *Amphispiza bilineata*
  Black-throated sparrow
- *Amphispiza belli*
  Sage sparrow
- *Junco oreganus*
  Oregon junco
- *Spizella passerina*
  Chipping sparrow
- *Zonotrichia leucophrys*
  White-crowned sparrow
- *Zonotrichia atricapilla*
  Golden-crowned sparrow
- *Zonotrichia albicollis*
  White-throated sparrow
- *Melospiza lincolnii*
  Lincoln sparrow
- *Melospiza melodia*
  Song sparrow
- *Passer domesticus*
  House sparrow

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